

PHOTOSYNTHESIS

R



WATER

CO₂

LIGHT ENERGY

PHOTO

ATMOSPHERE

E-

PHOTOLYSIS



LT RXT
THYLAKOID

CHEMICAL ENERGY

DK RXT
STROMA

CHLOROPLAST

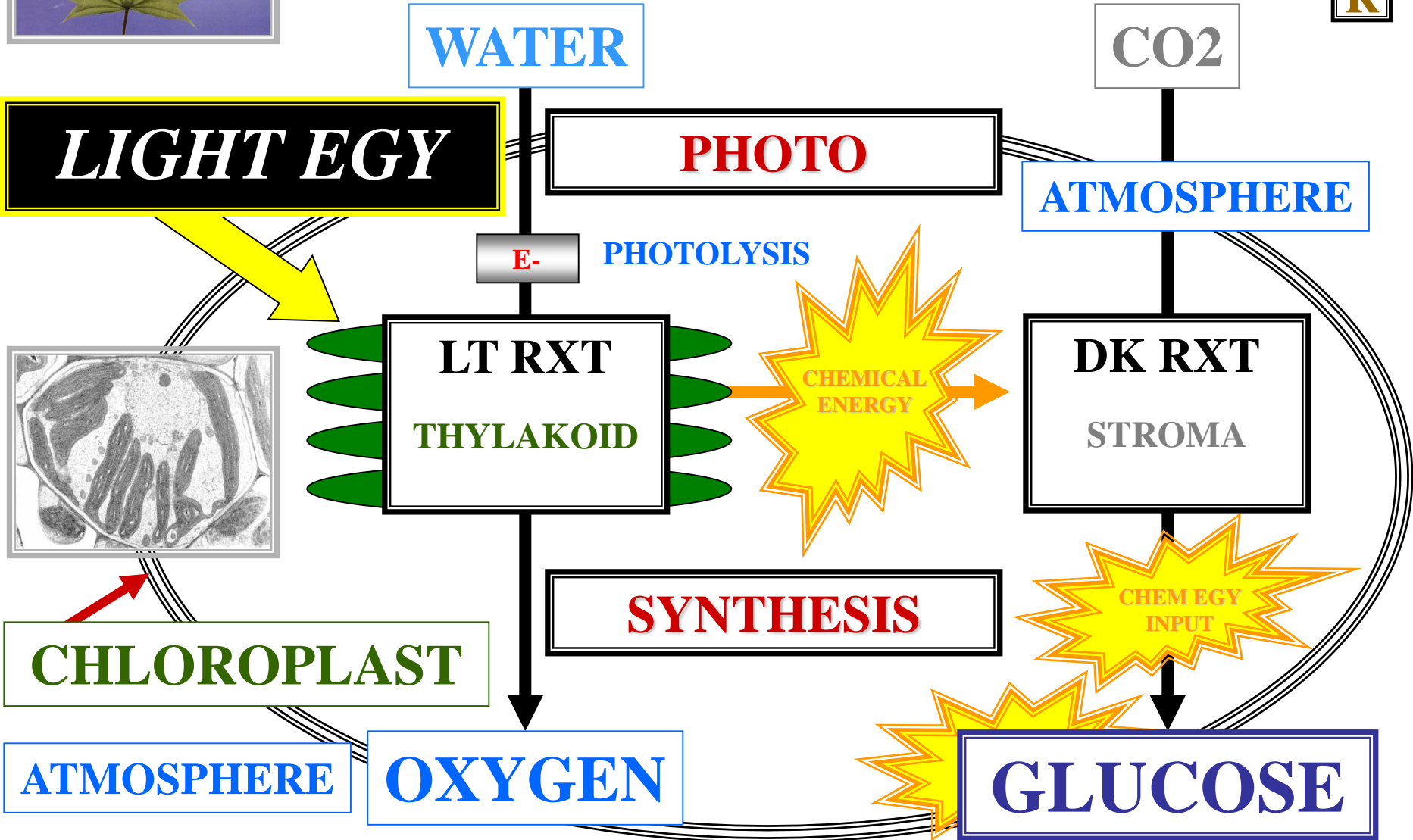
SYNTHESIS

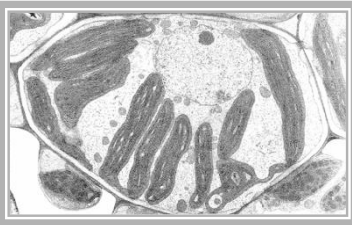
CHEMICAL ENERGY INPUT

ATMOSPHERE

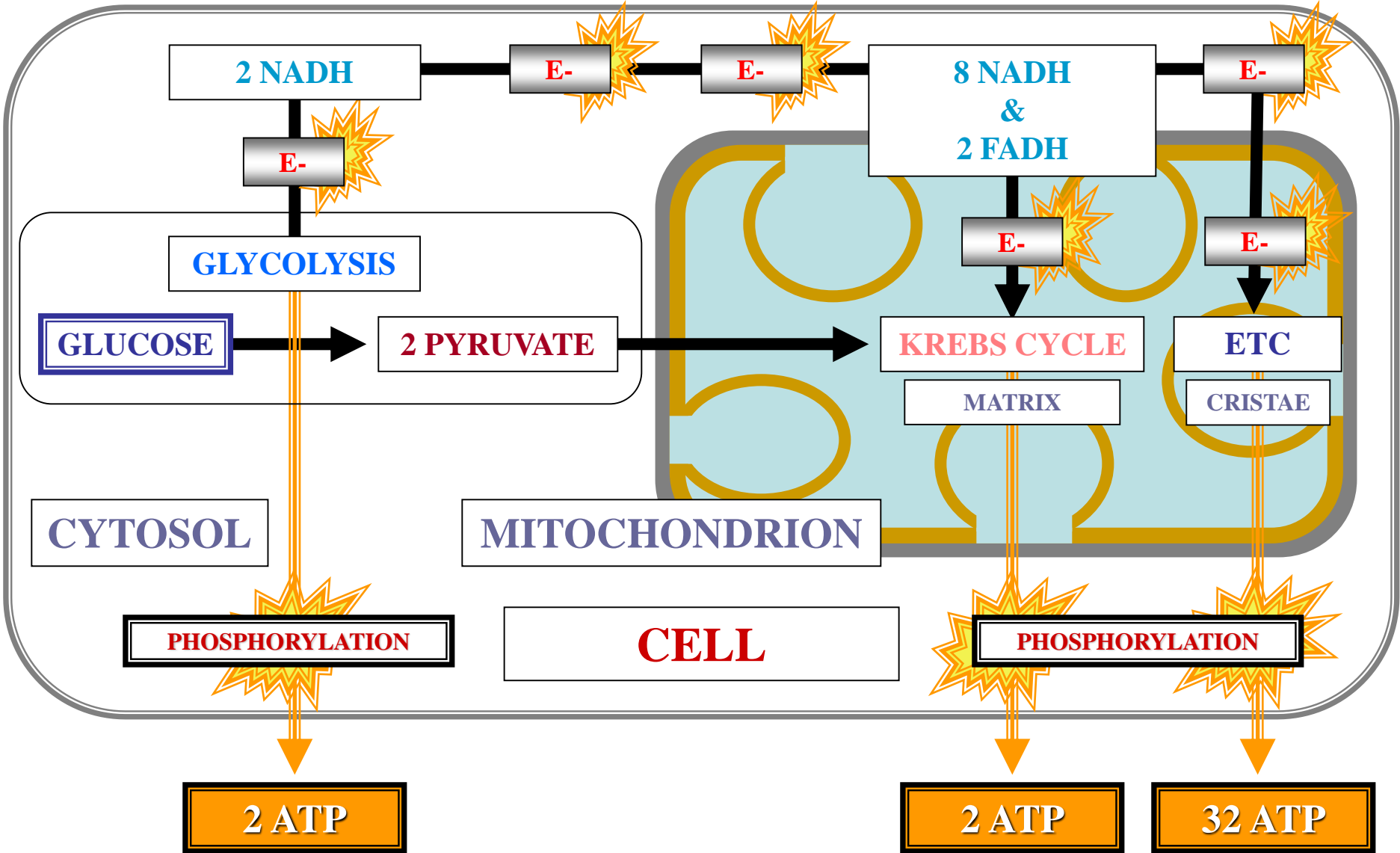
OXYGEN

GLUCOSE





RESPIRATION



EXAMPLE
C14
BIOCHEMICAL
TRACER

PHOTOSYNTHESIS

CC



WATER

CO₂

LIGHT ENERGY

PHOTO

ATMOSPHERE

E-

PHOTOLYSIS



LT RXT
THYLAKOID

CHEMICAL ENERGY

DK RXT
STROMA

CHLOROPLAST

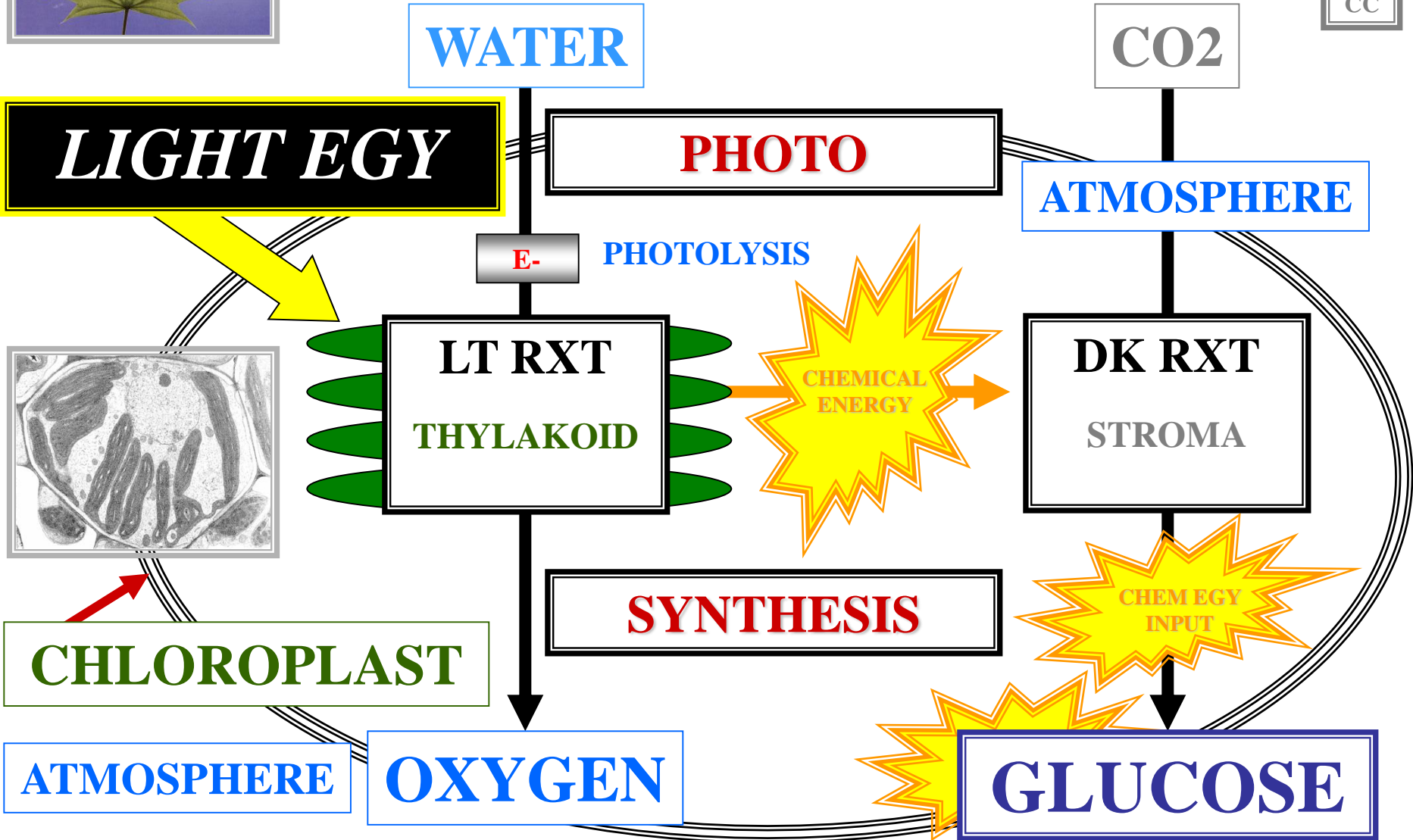
SYNTHESIS

CHEMICAL ENERGY INPUT

ATMOSPHERE

OXYGEN

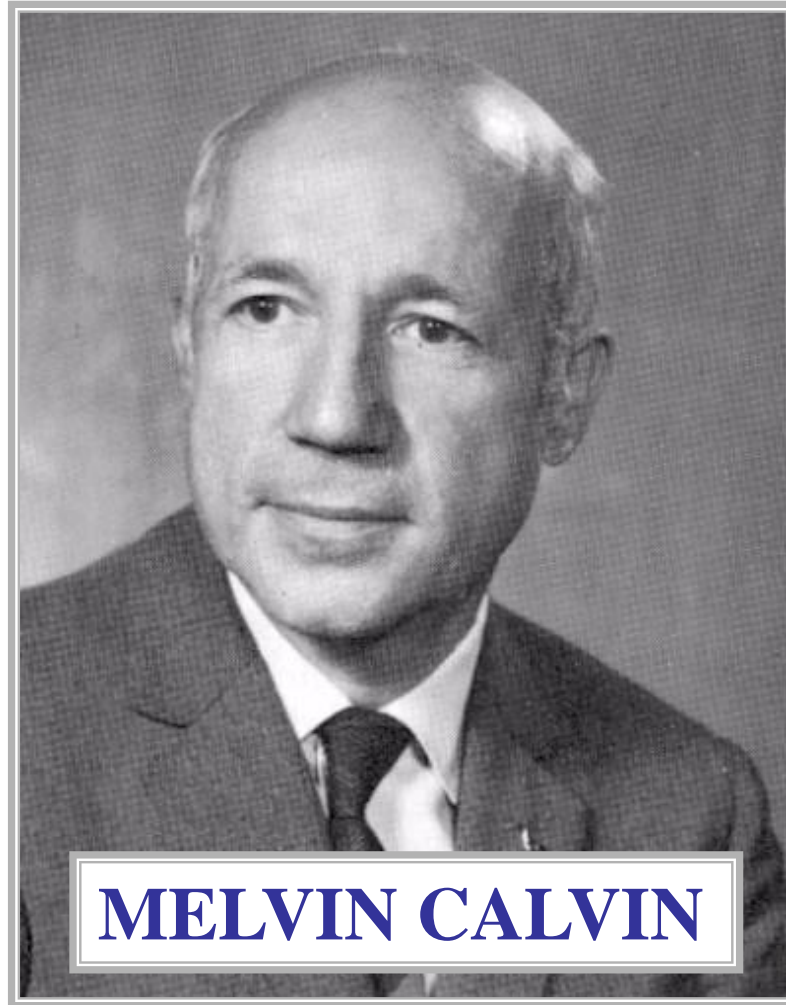
GLUCOSE





DARK REACTION
CALVIN CYCLE
OF
PHOTOSYNTHESIS

C14: BIOCHEMICAL TRACER



BIOCHEMIST
PHOTOSYNTHESIS

QUESTION

WHAT DO BIOLOGISTS
CALL THE STUDY OF
BIOCHEMISTRY?

QUESTION

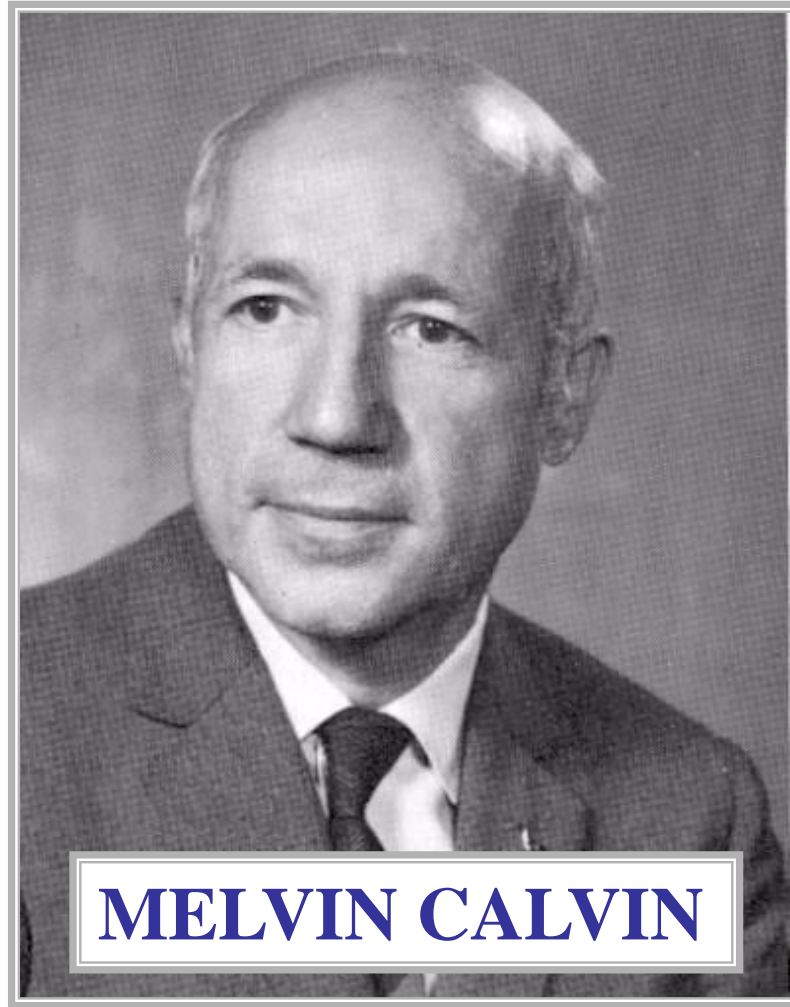


ANSWER

PHYSIOLOGY

ANSWER

C14: BIOCHEMICAL TRACER



**PLANT PHYSIOLOGIST
PHOTOSYNTHESIS**

PHOTOSYNTHESIS



WATER

CO₂

C¹⁴



LIGHT ENERGY

PHOTO

ATMOSPHERE

E⁻

PHOTOLYSIS

LT RXT

THYLAKOID

CHEMICAL ENERGY

DK RXT

STROMA

CHEMICAL ENERGY INPUT

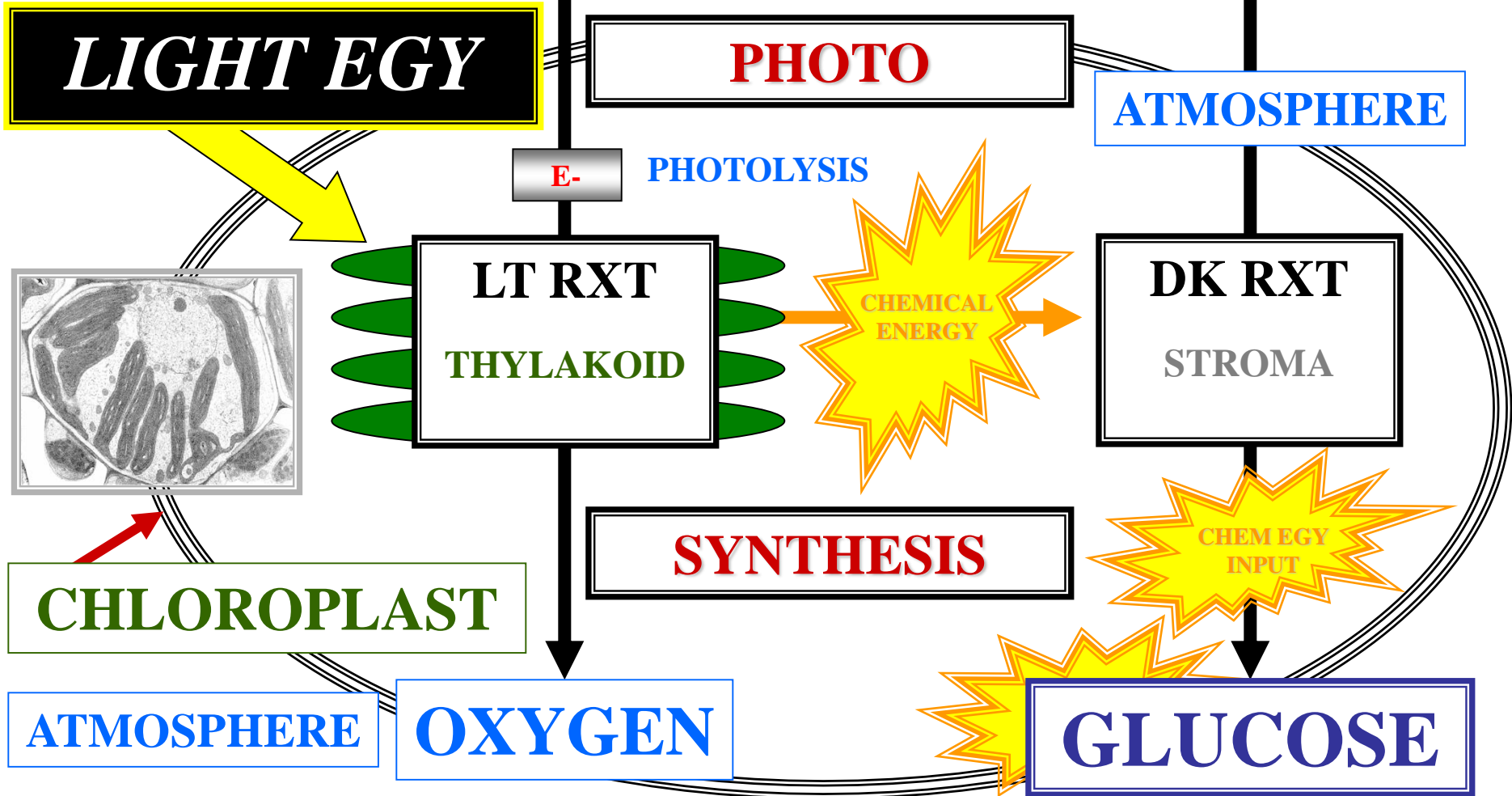
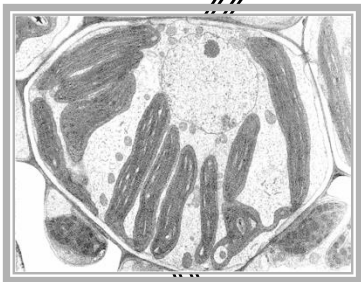
SYNTHESIS

CHLOROPLAST

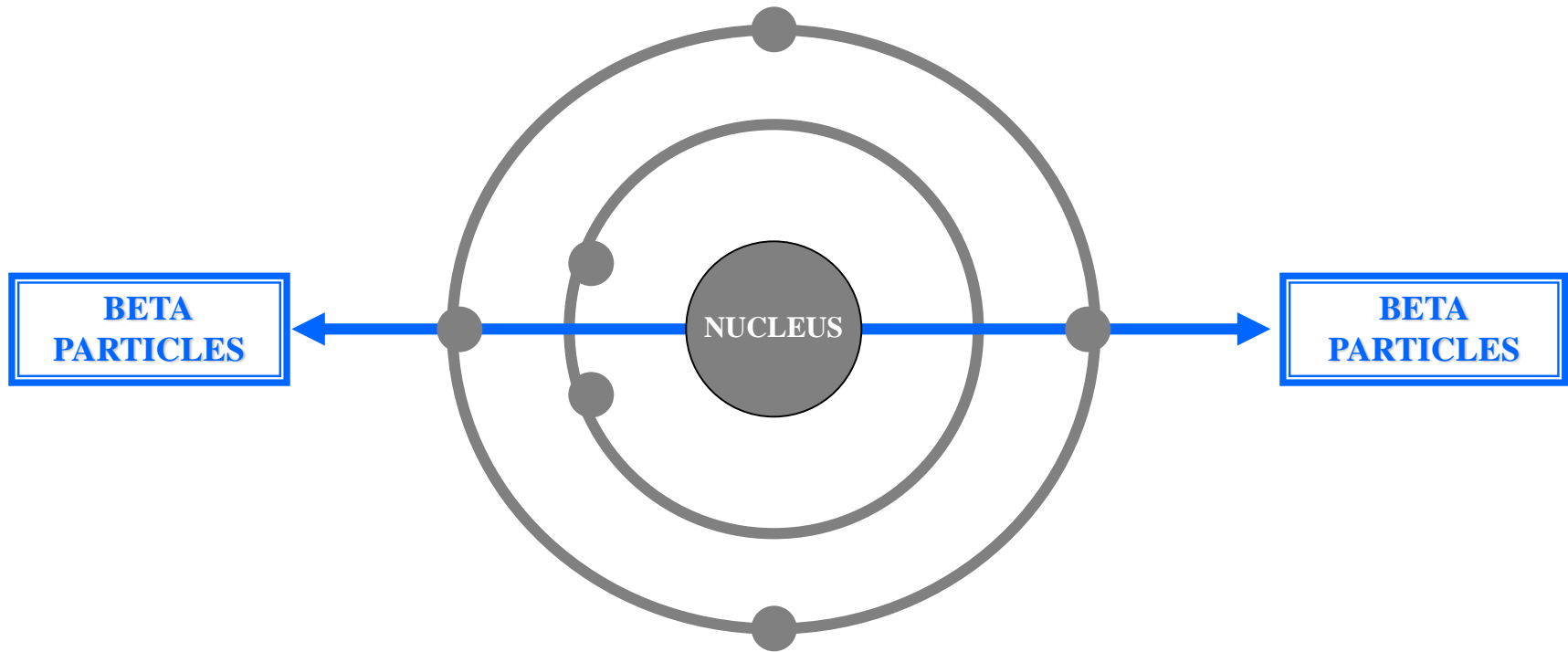
ATMOSPHERE

OXYGEN

GLUCOSE



C14 BIOCHEMICAL TRACER



EMITS **BETA** PARTICLES

C14

● = e-

C14

CO₂ + RIBULOSE BISPHOSPHATE / (RUBP)

**RIBULOSE BISPHOSPHATE
CARBOXYLASE
(RUBP-CARBOXYLASE)**

UNSTABLE C6 INTERMEDIATE

PHOSPHOGLYCERATE / (PGA)

PHOSPHOGLYCERATE / (PGA)

ATP

ATP

BISPHOGLYCERATE / (BIPGA)

BISPHOGLYCERATE / (BIPGA)

NADPH

NADPH

PHOSPHOGLYCERALDEHYDE / (PGAL)

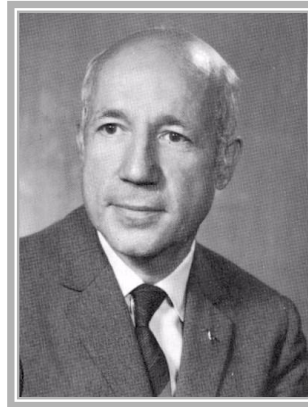
PHOSPHOGLYCERALDEHYDE / (PGAL)

**COMPLEX SERIES
CHEMICAL RXTS
(CSCR)**

**COMPLEX SERIES
CHEMICAL RXTS
(CSCR)**

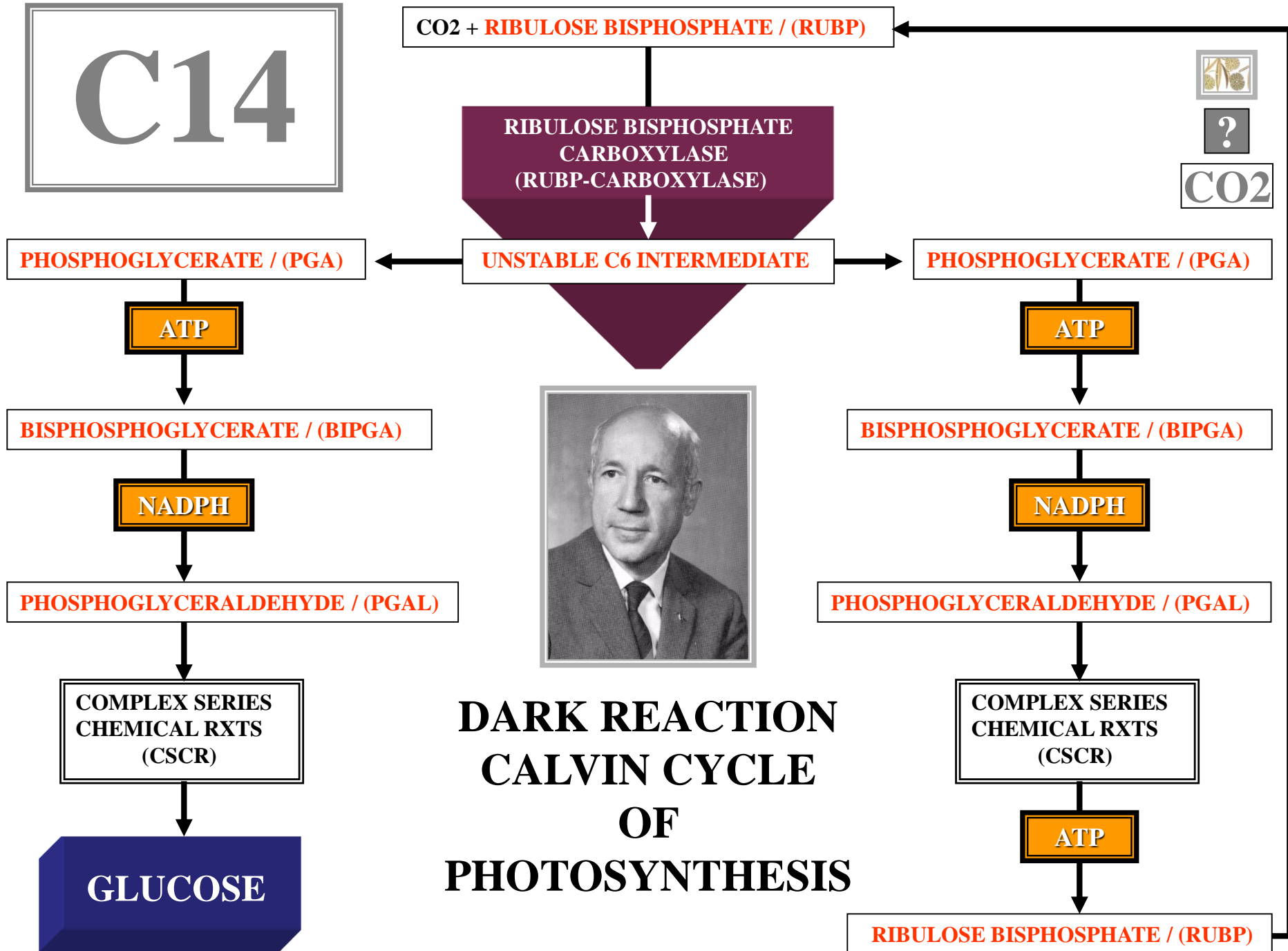
GLUCOSE

**DARK REACTION
CALVIN CYCLE
OF
PHOTOSYNTHESIS**



CO₂

RIBULOSE BISPHOSPHATE / (RUBP)



P

?

CO₂



PHOTOSYNTHESIS

GREEN ALGAE

PHOTOSYNTHESIS

C



WATER

?

LIGHT ENERGY

PHOTO

ATMOSPHERE

E-

PHOTOLYSIS



LT RXT
THYLAKOID

CHEMICAL ENERGY

DK RXT
STROMA

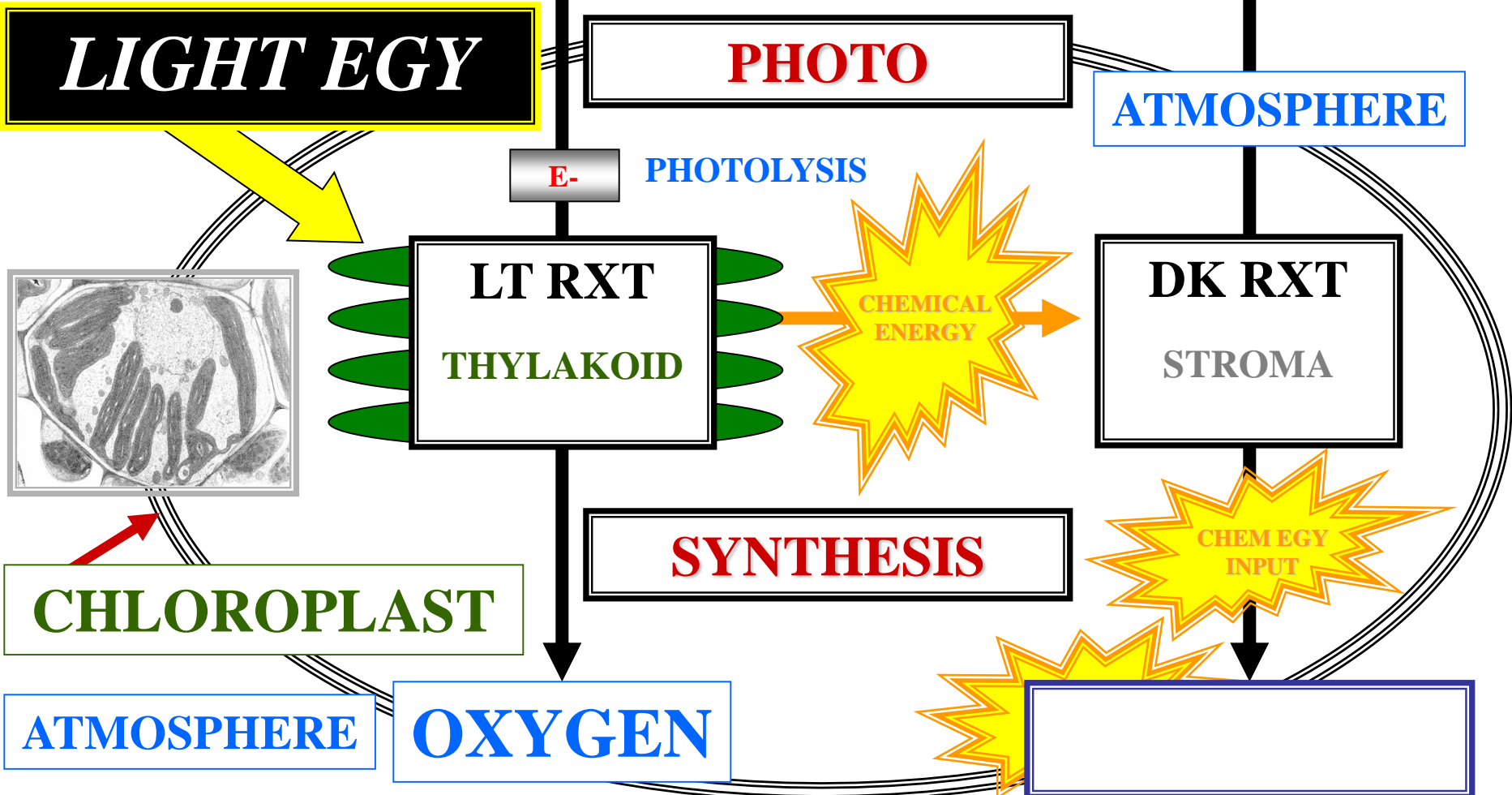
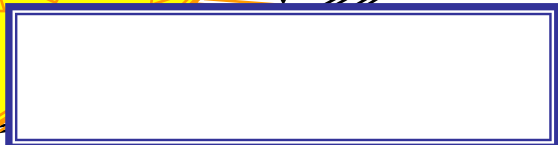
CHLOROPLAST

SYNTHESIS

CHEMICAL ENERGY INPUT

ATMOSPHERE

OXYGEN



PHOTOSYNTHESIS

G



WATER

CO₂

LIGHT ENERGY

PHOTO

ATMOSPHERE

E-

PHOTOLYSIS



LT RXT
THYLAKOID

CHEMICAL ENERGY

DK RXT
STROMA

CHLOROPLAST

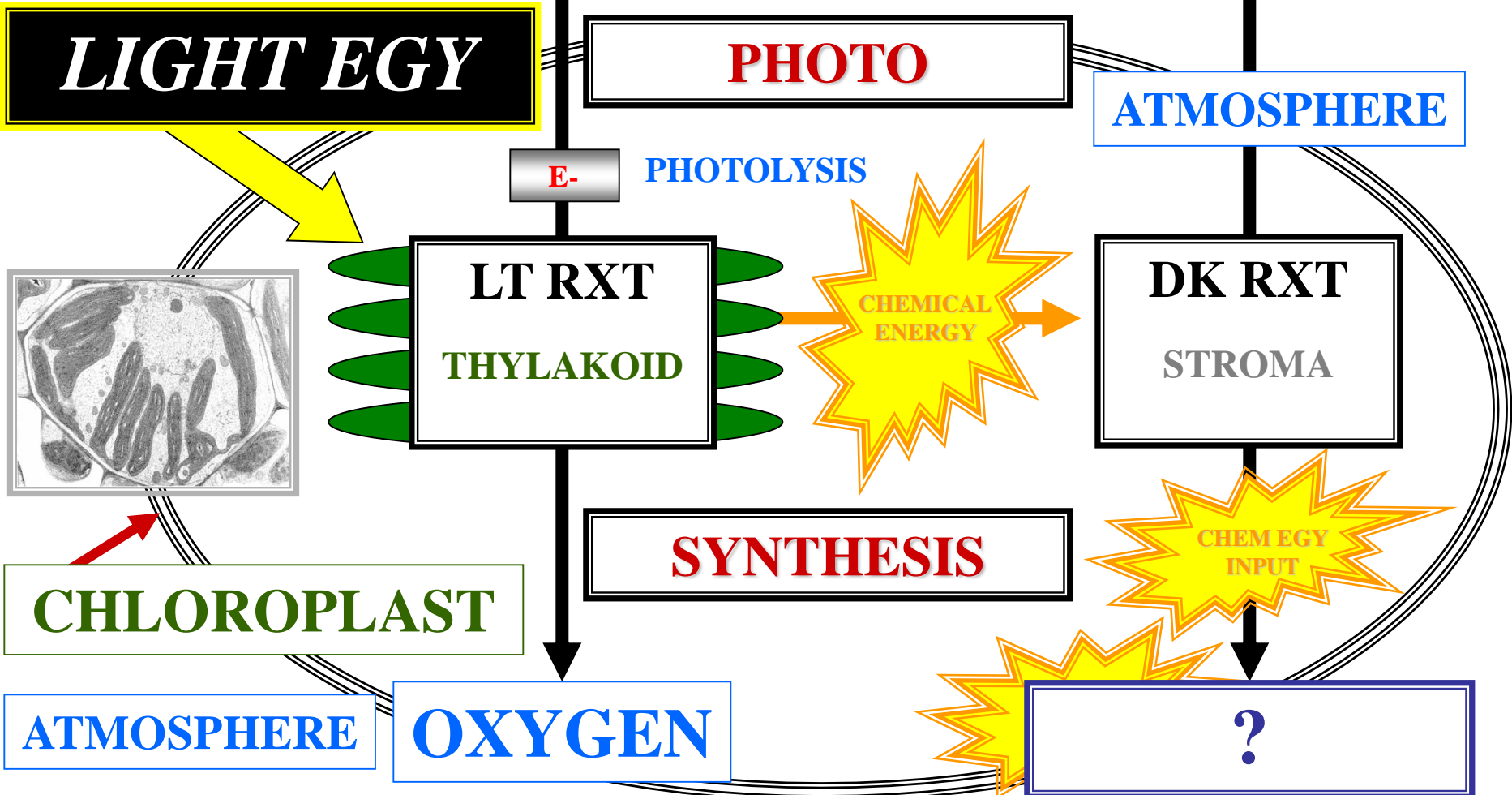
SYNTHESIS

CHEMICAL ENERGY INPUT

ATMOSPHERE

OXYGEN

?



PHOTOSYNTHESIS

CO₂

WATER

CO₂

LIGHT ENERGY

PHOTO

ATMOSPHERE

E-

PHOTOLYSIS

LT RXT

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SYNTHESIS

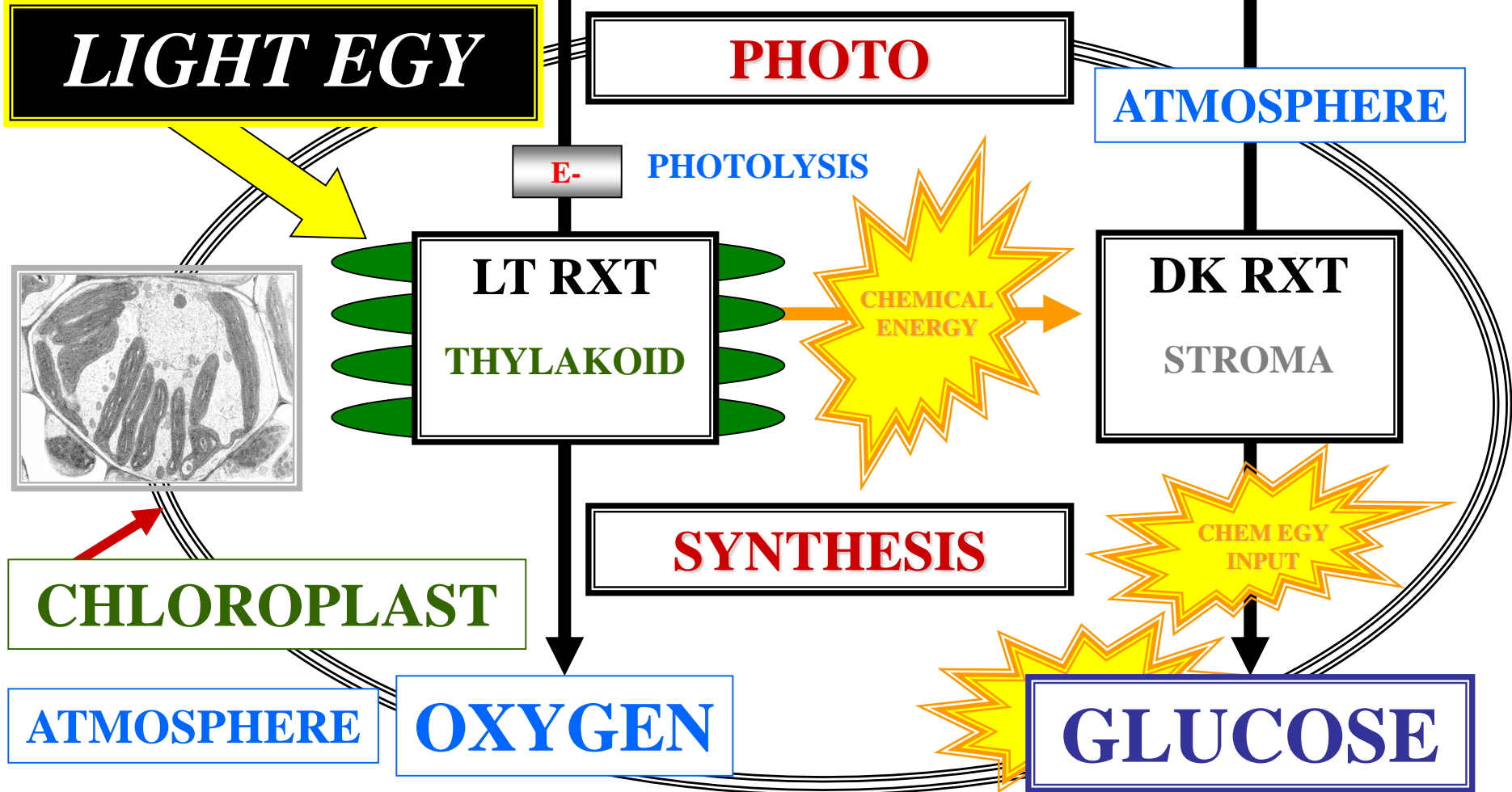
CHEMICAL ENERGY INPUT

CHLOROPLAST

ATMOSPHERE

OXYGEN

GLUCOSE



PHOTOSYNTHESIS



CO₂
CO₂
CO₂
CO₂
CO₂
CO₂



CARBON DIOXIDE

CARBON DIOXIDE
BUILDING BLOCK

PHOTOSYNTHESIS

CARBON DIOXIDE

CO₂
CO₂
CO₂
CO₂
CO₂
CO₂



SYNTHESIZE

CARBON DIOXIDE
BUILDING BLOCK

PHOTOSYNTHESIS

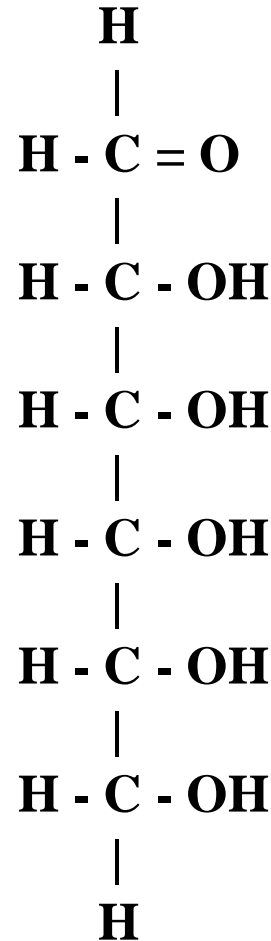


CARBON DIOXIDE

CO₂
CO₂
CO₂
CO₂
CO₂
CO₂



SYNTHESIZE



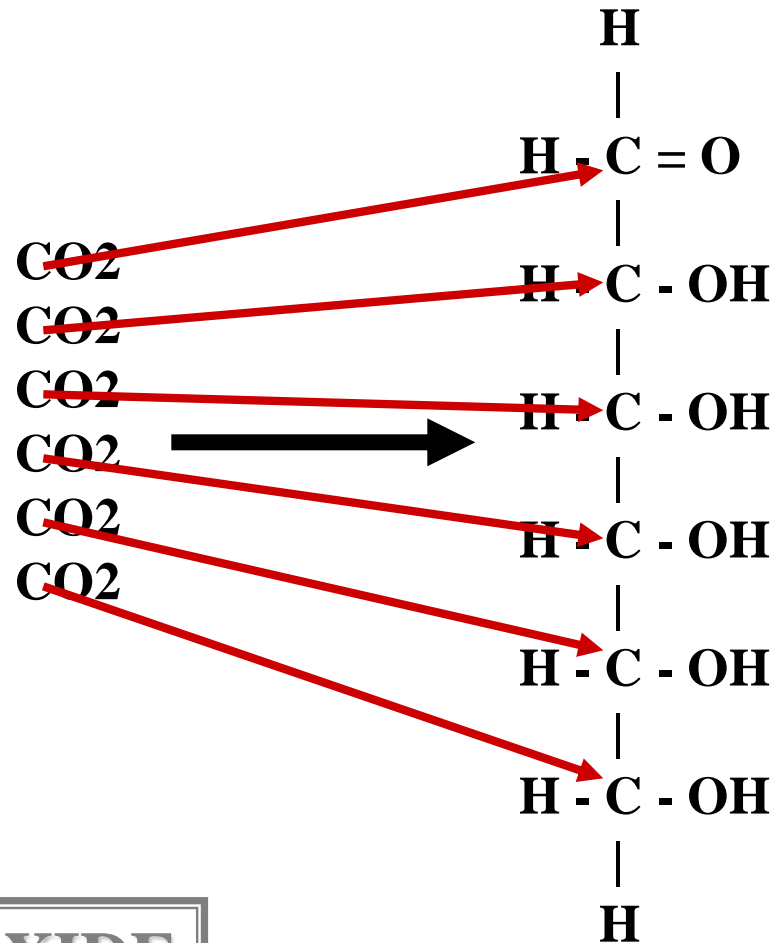
CARBON DIOXIDE
BUILDING BLOCK

C₆H₁₂O₆

GLUCOSE

PHOTOSYNTHESIS

C12

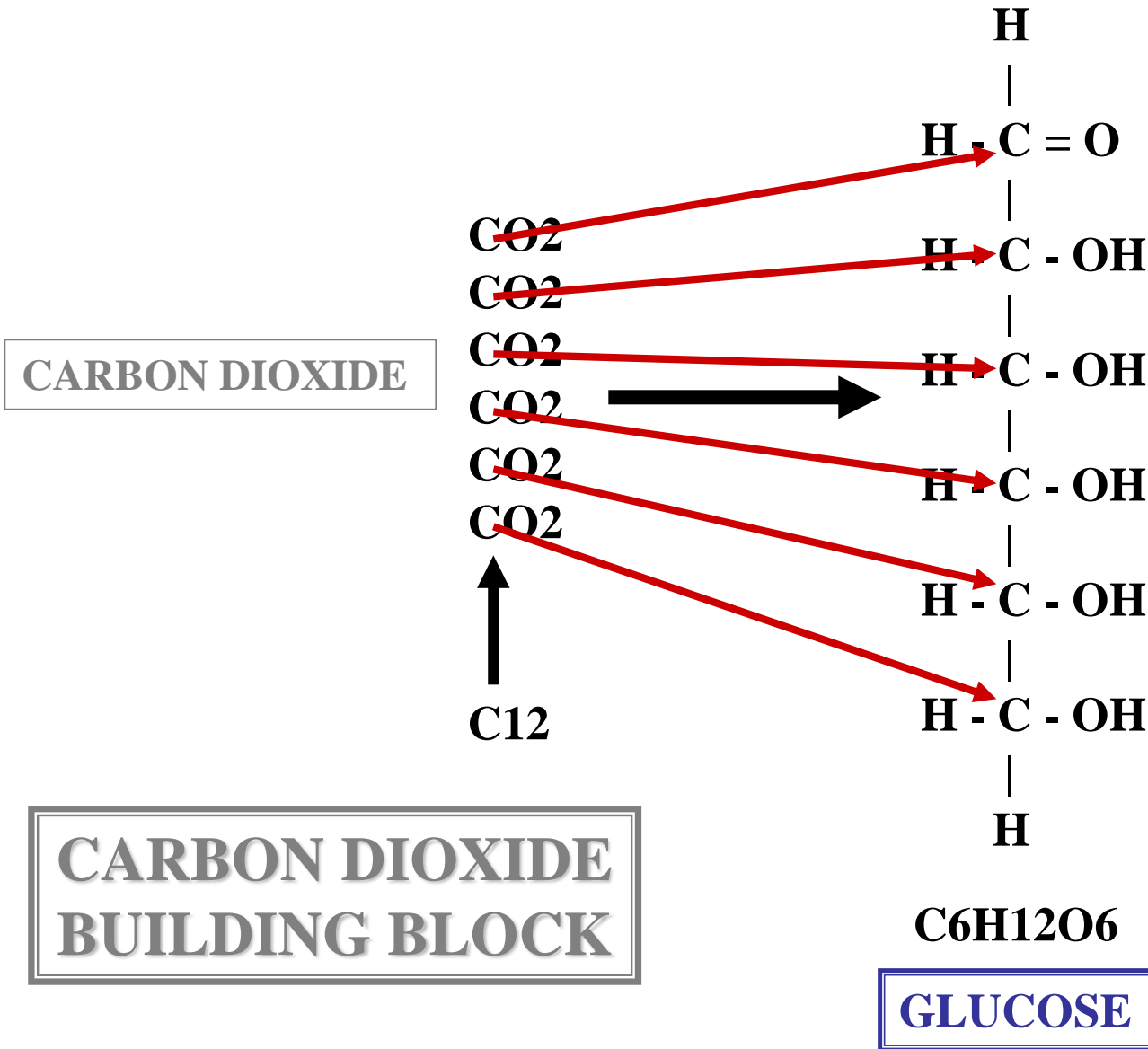


CARBON DIOXIDE

CARBON DIOXIDE
BUILDING BLOCK

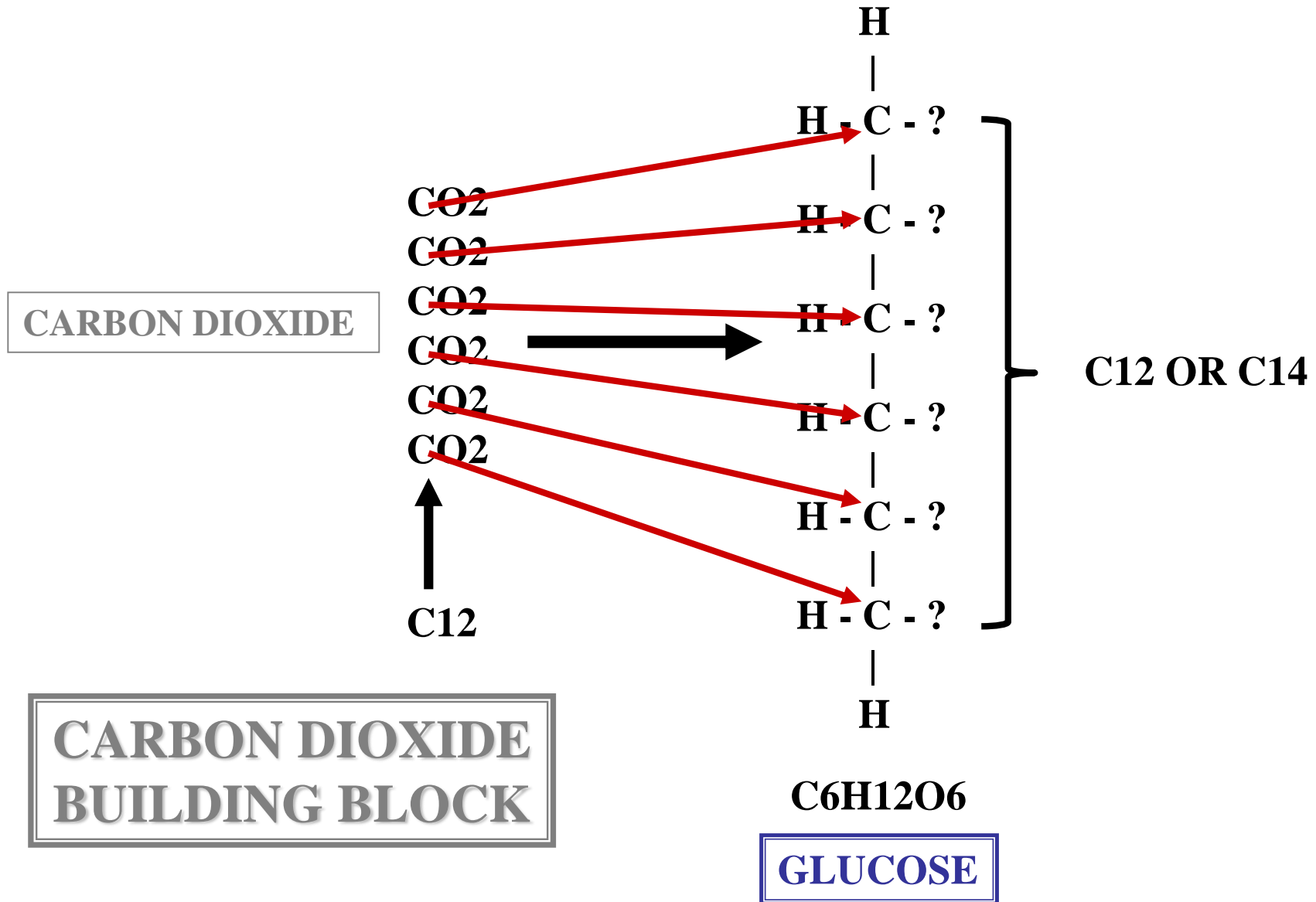
GLUCOSE

PHOTOSYNTHESIS

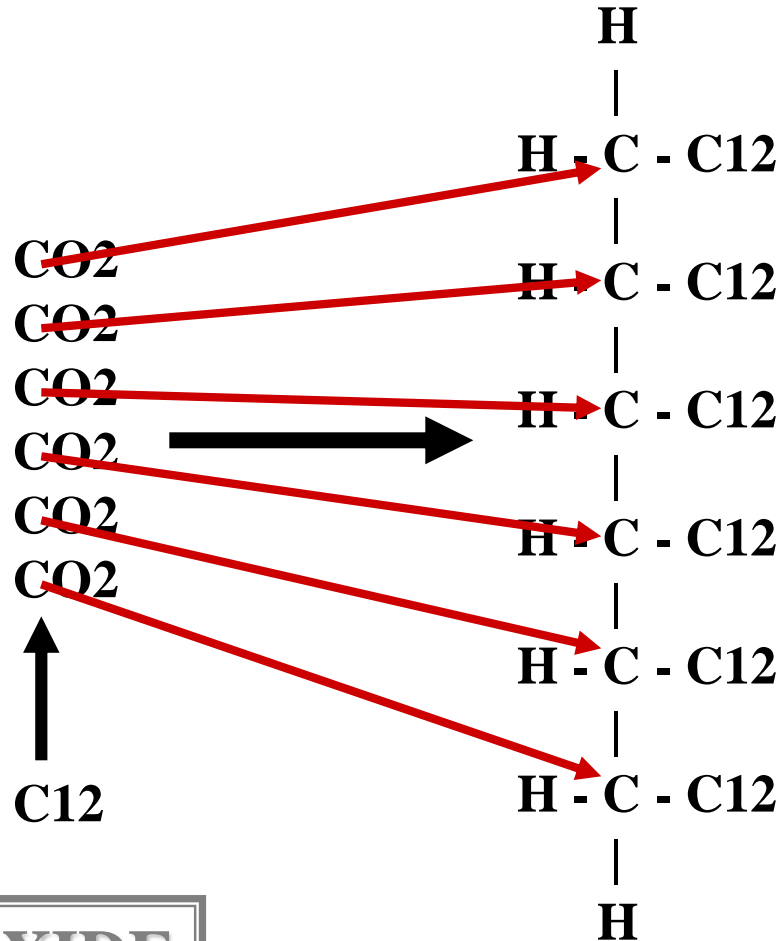


PHOTOSYNTHESIS

C12



PHOTOSYNTHESIS



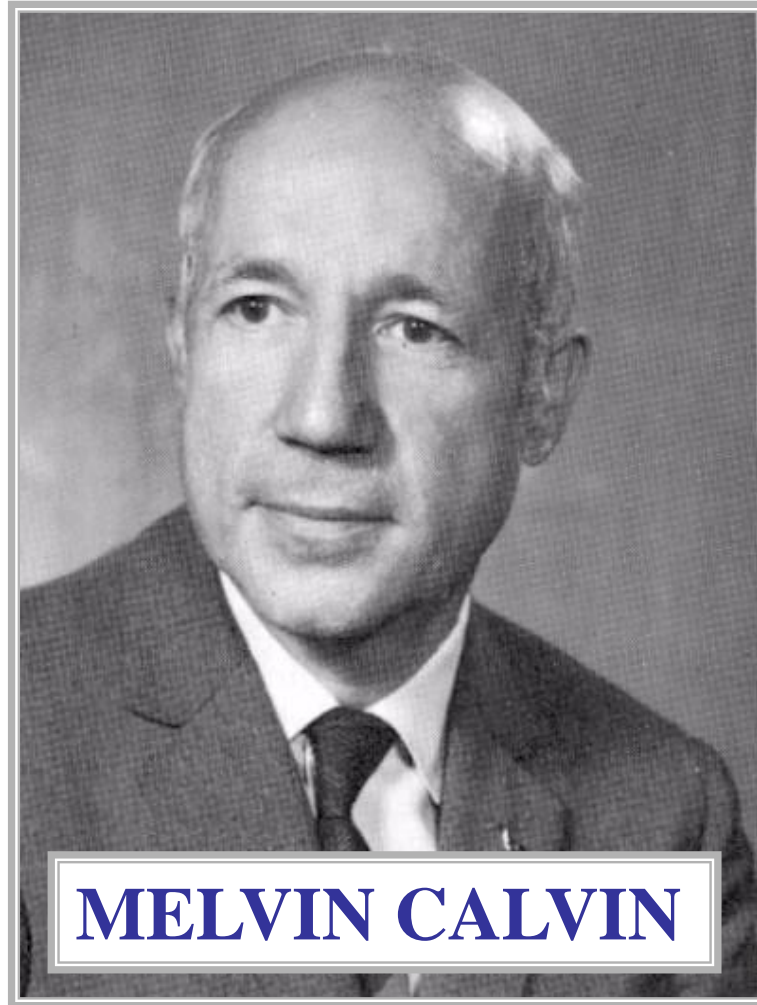
CARBON DIOXIDE

CARBON DIOXIDE
BUILDING BLOCK

C6H12O6

GLUCOSE

C14: BIOCHEMICAL TRACER



**PLANT PHYSIOLOGIST
UTILIZED C14 ISOTOPES**



PHOTOSYNTHESIS

GREEN ALGAE

PHOTOSYNTHESIS

C14

CARBON DIOXIDE

CO₂

CO₂

CO₂

CO₂

CO₂

CO₂



C12



CARBON DIOXIDE
BUILDING BLOCK

PHOTOSYNTHESIS



CARBON DIOXIDE

CO₂
CO₂
CO₂
CO₂
CO₂
CO₂



C₁₄

CARBON DIOXIDE
BUILDING BLOCK

PHOTOSYNTHESIS

CARBON DIOXIDE

CO₂
CO₂
CO₂
CO₂
CO₂
CO₂



SYNTHESIZE



C14

CARBON DIOXIDE
BUILDING BLOCK

PHOTOSYNTHESIS



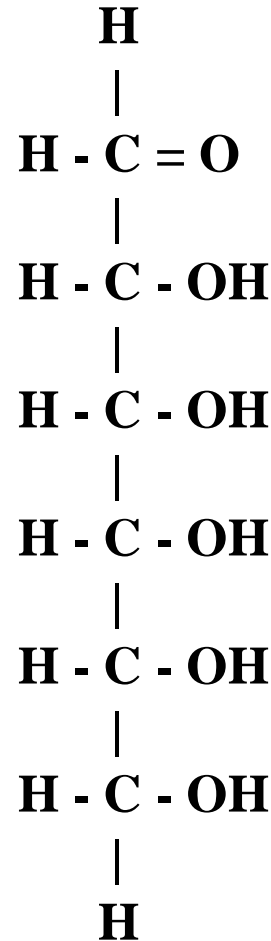
CARBON DIOXIDE

CO₂
CO₂
CO₂
CO₂
CO₂
CO₂

↑
C₁₄



SYNTHESIZE

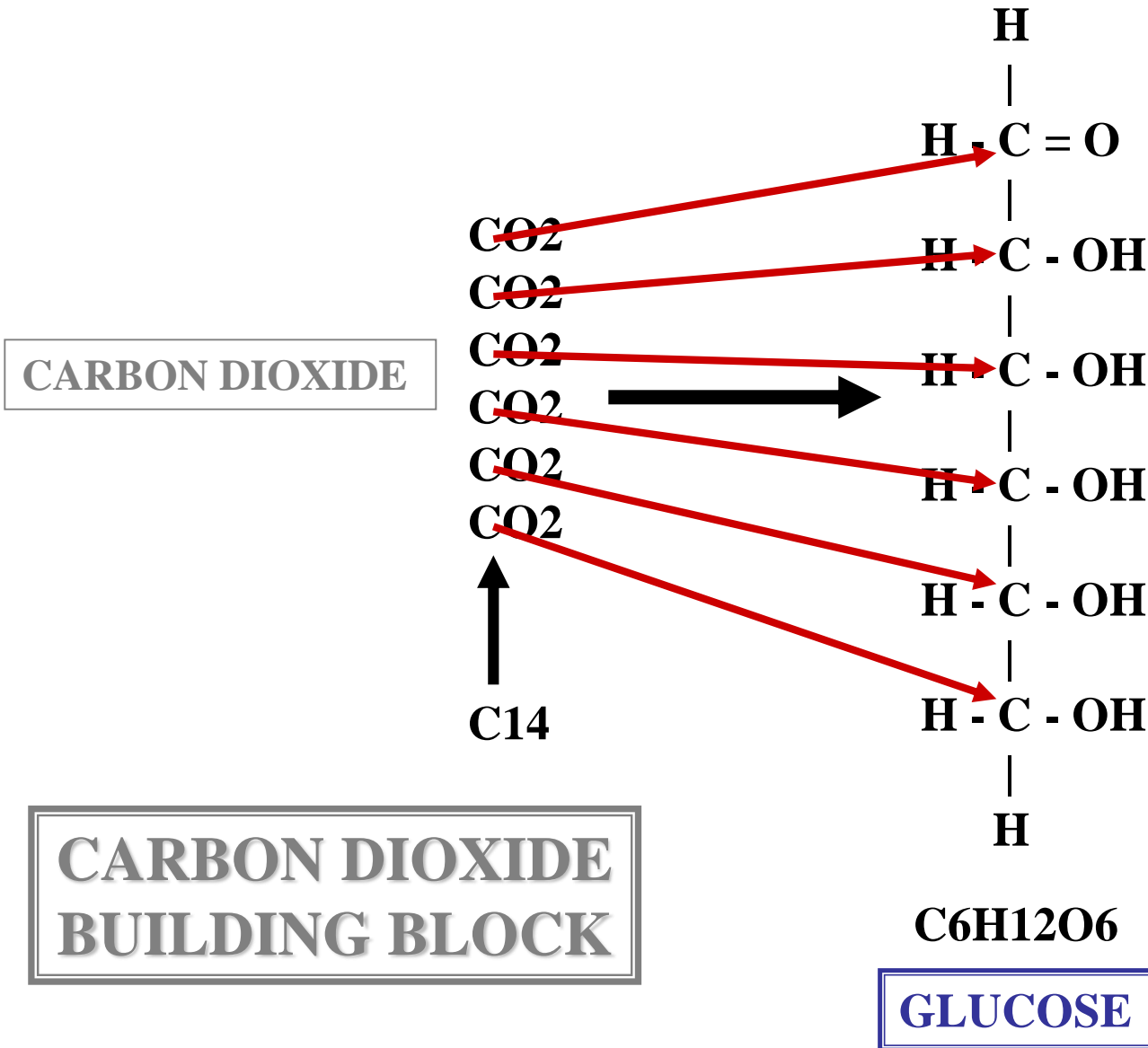


C₆H₁₂O₆

GLUCOSE

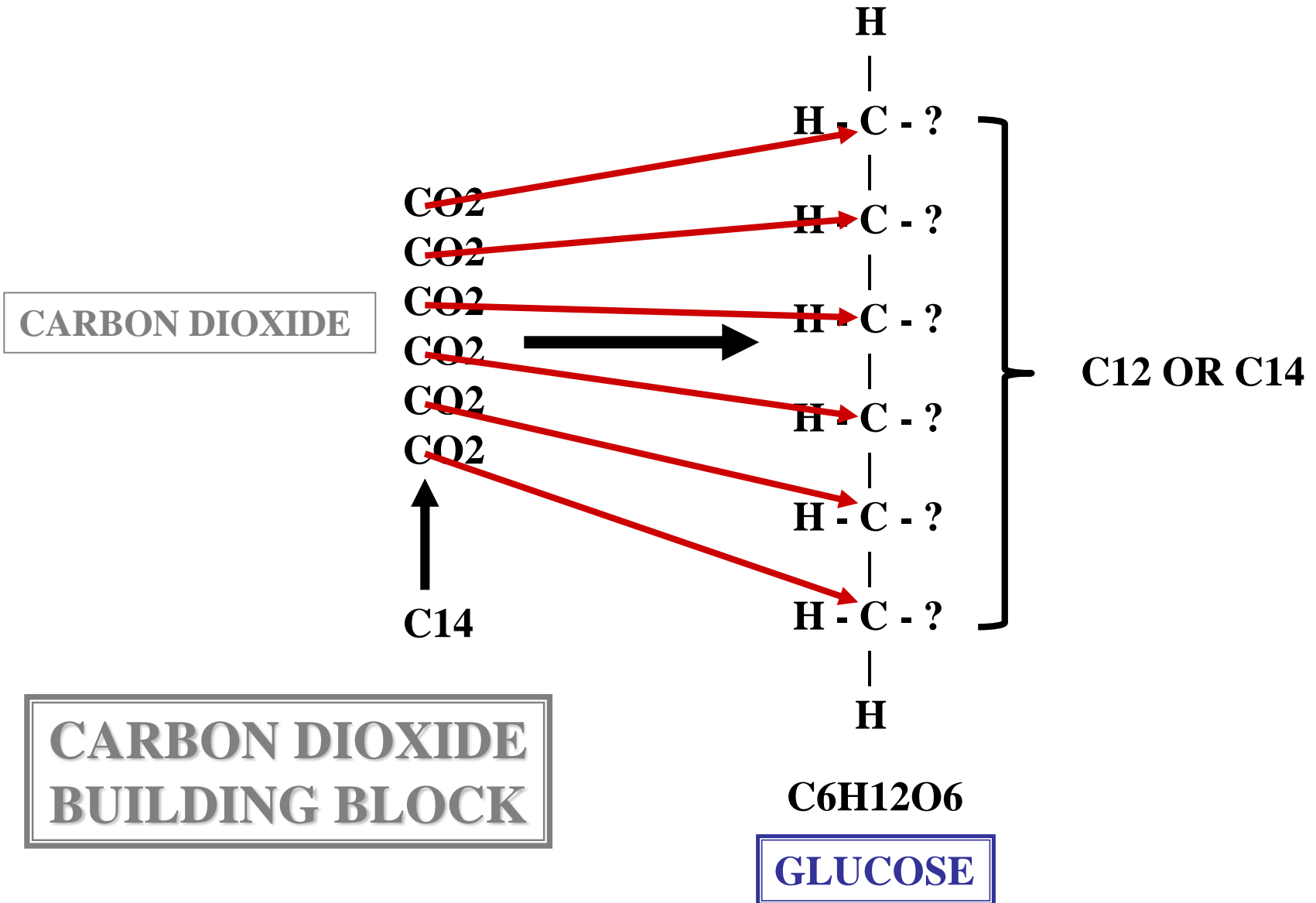
CARBON DIOXIDE
BUILDING BLOCK

PHOTOSYNTHESIS



PHOTOSYNTHESIS

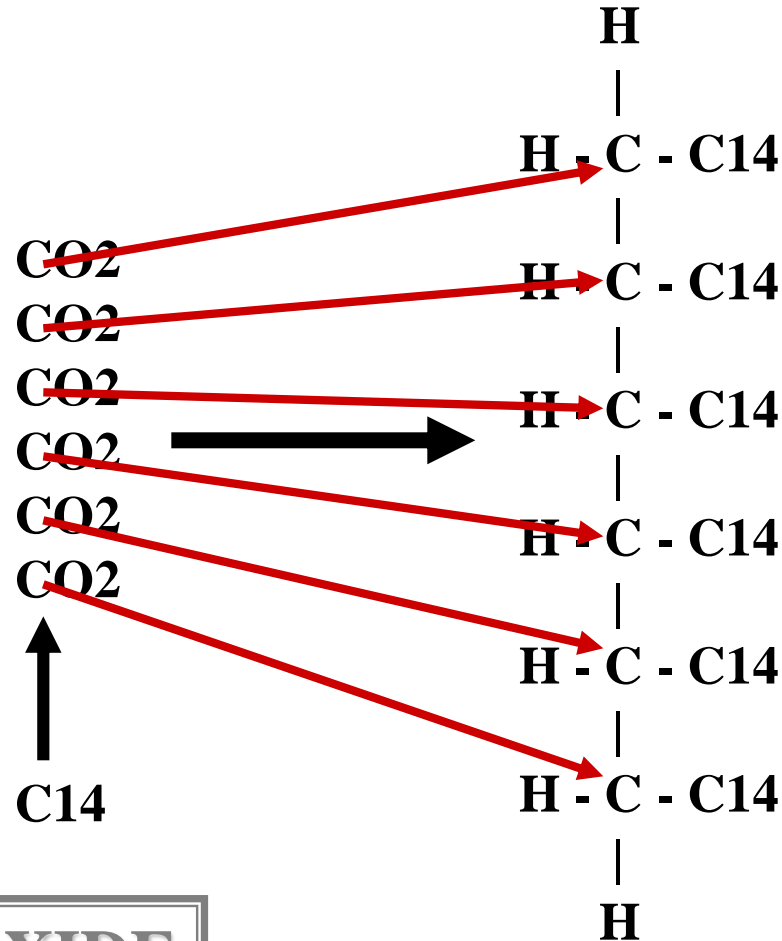
C14



PHOTOSYNTHESIS

C14

B



CARBON DIOXIDE

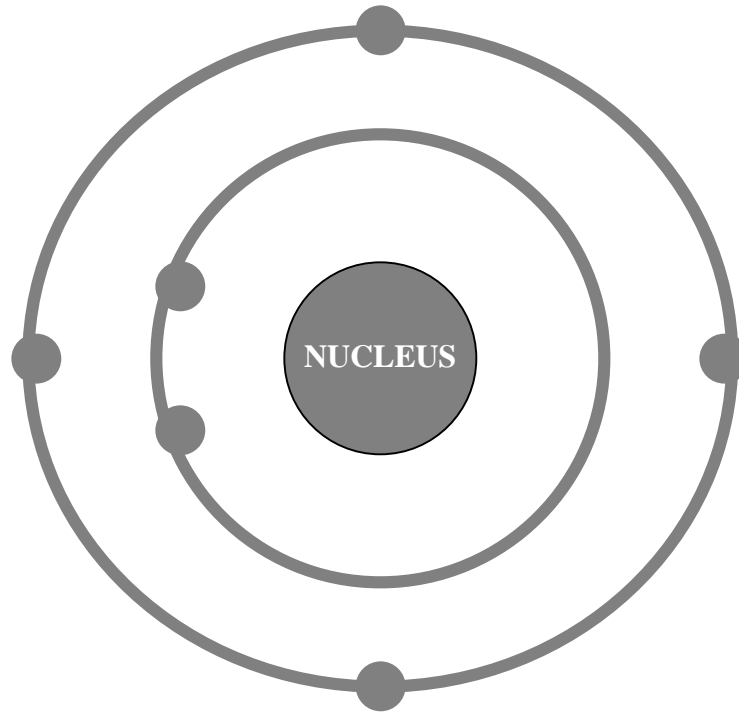
CARBON DIOXIDE
BUILDING BLOCK

$\text{C}_6\text{H}_{12}\text{O}_6$

GLUCOSE

RADIOACTIVE ISOTOPE

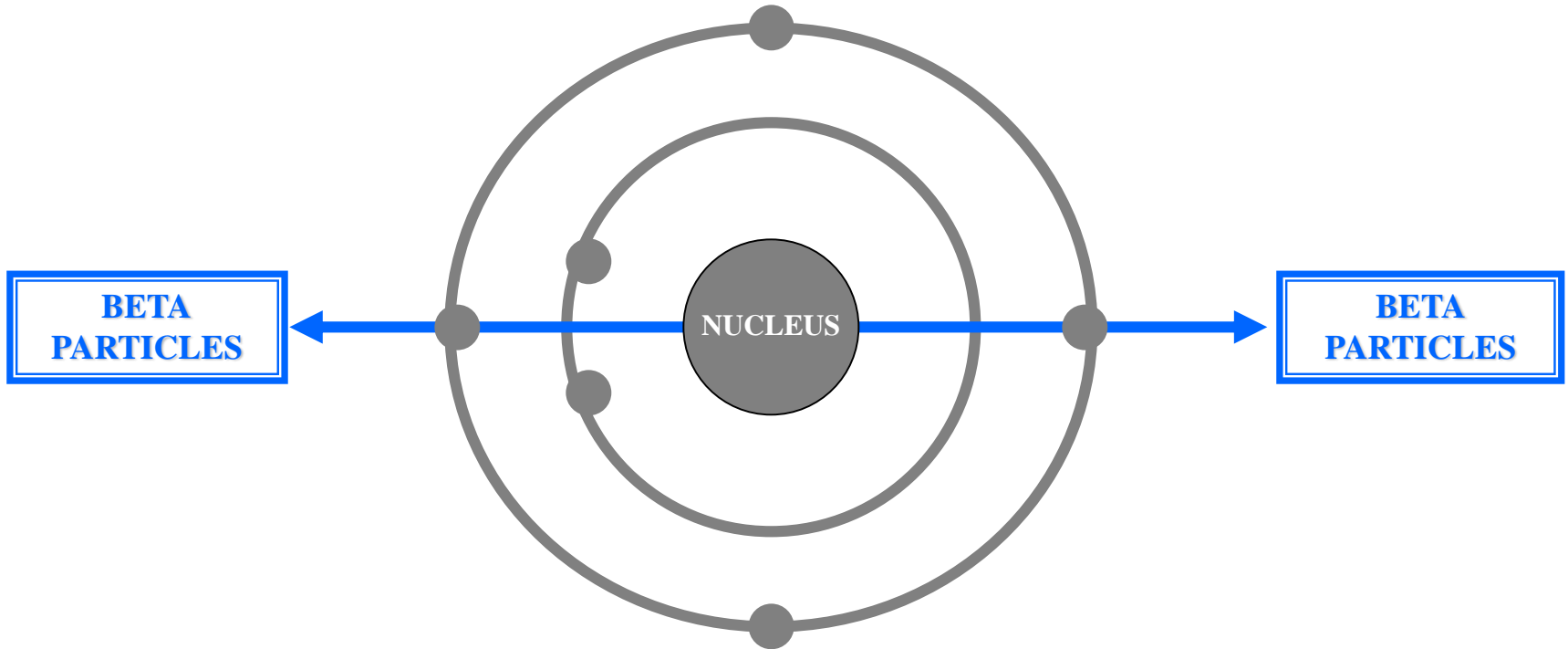
UNSTABLE ISOTOPE



C14

● = e-

RADIOACTIVE ISOTOPE UNSTABLE ISOTOPE



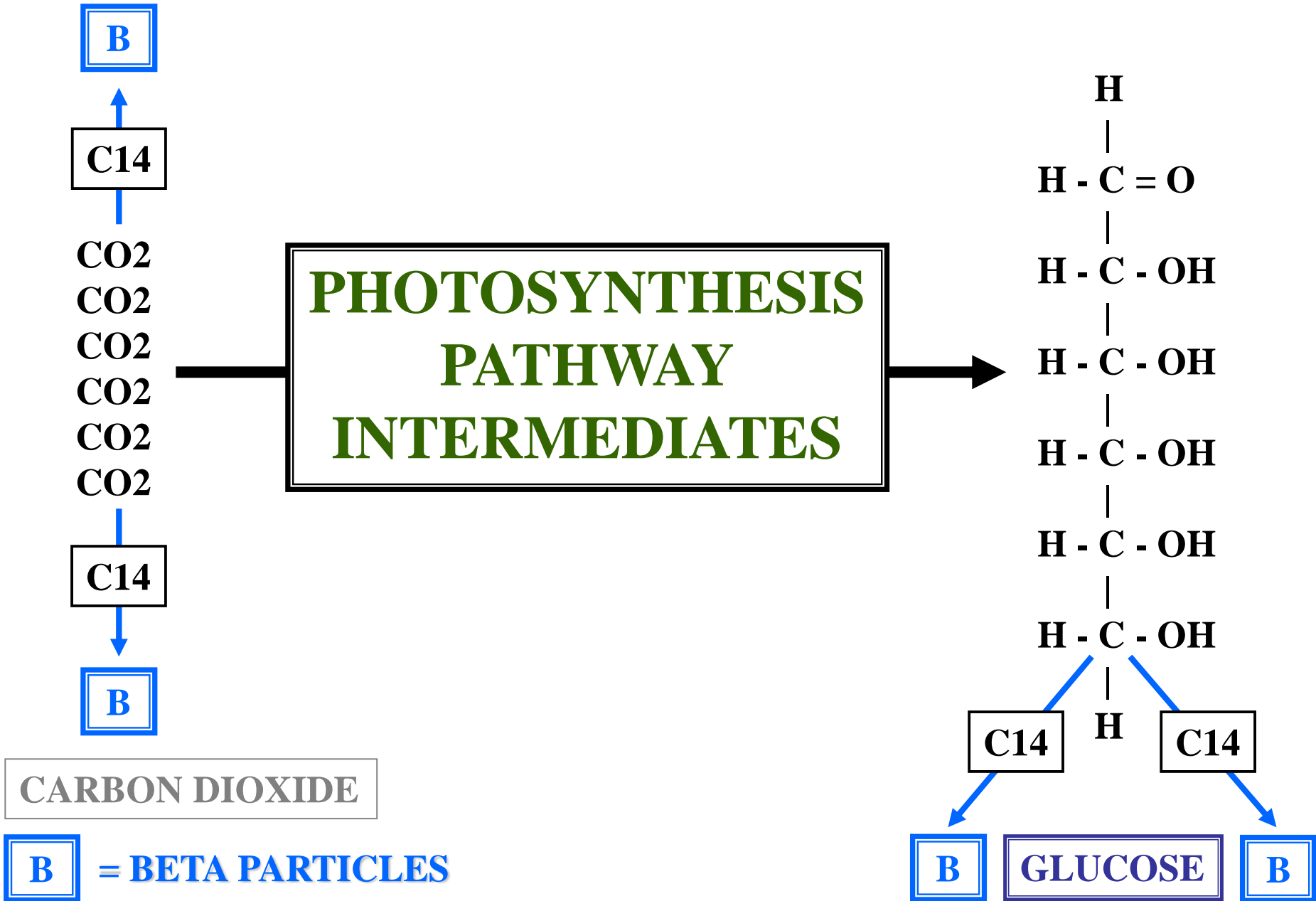
EMITS **BETA** PARTICLES

C14

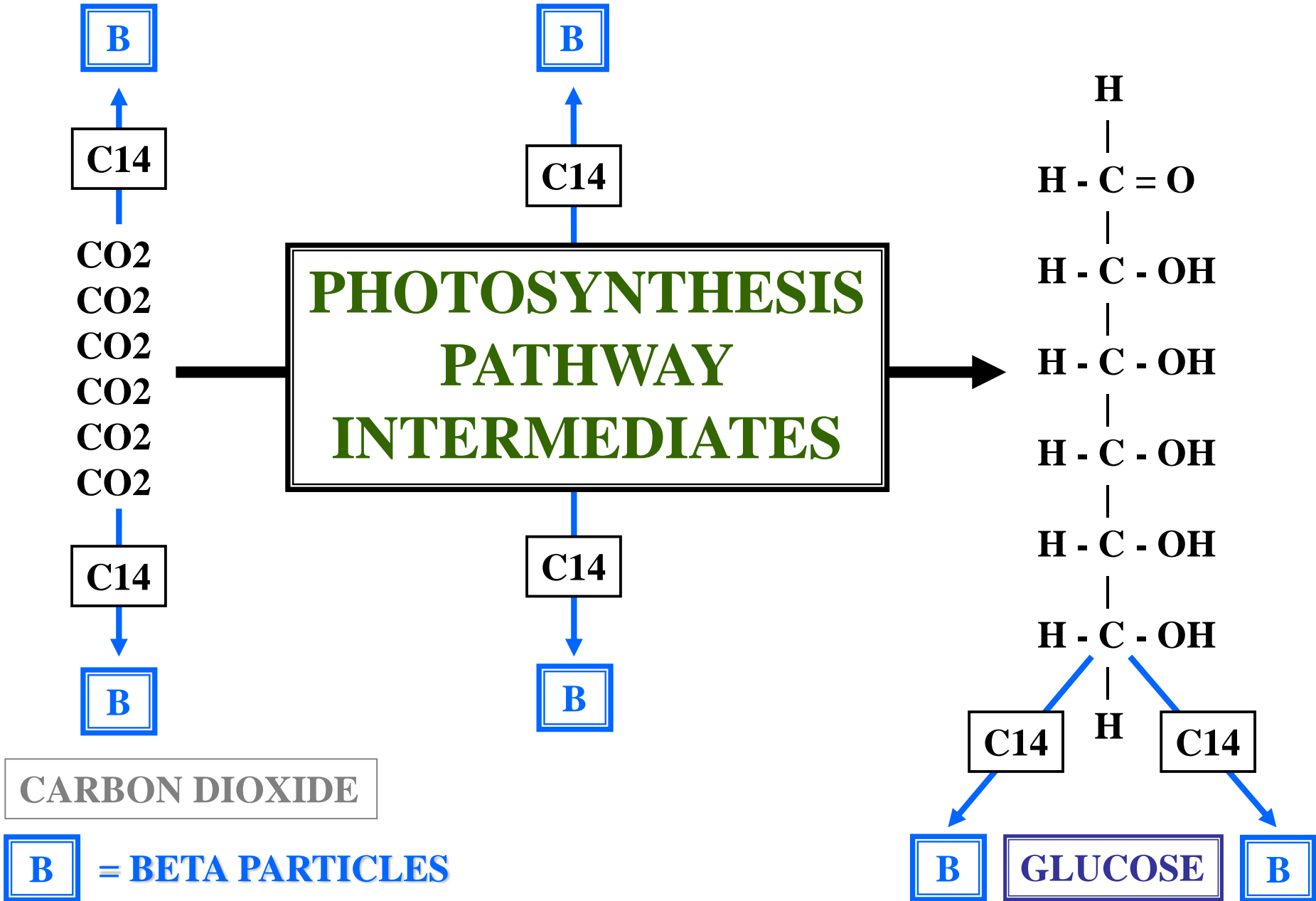
● = e-

C14: BIOCHEMICAL TRACER

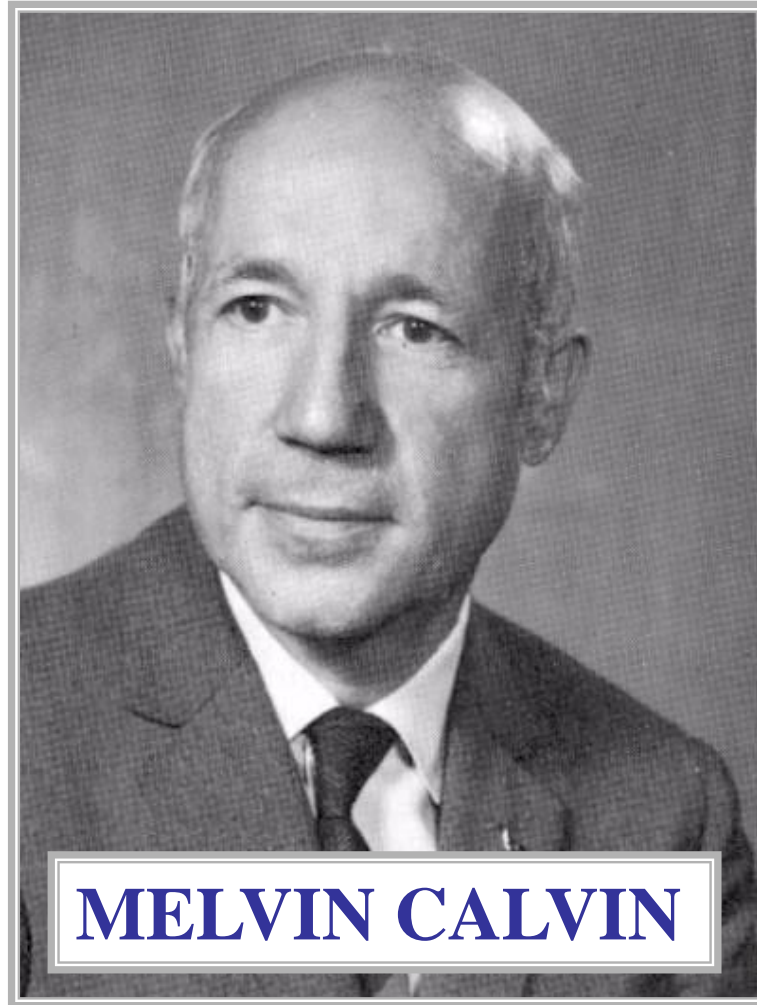
B



C14: BIOCHEMICAL TRACER



C14: BIOCHEMICAL TRACER



**PLANT PHYSIOLOGIST
UTILIZED C14 ISOTOPES**



PHOTOSYNTHESIS

GREEN ALGAE

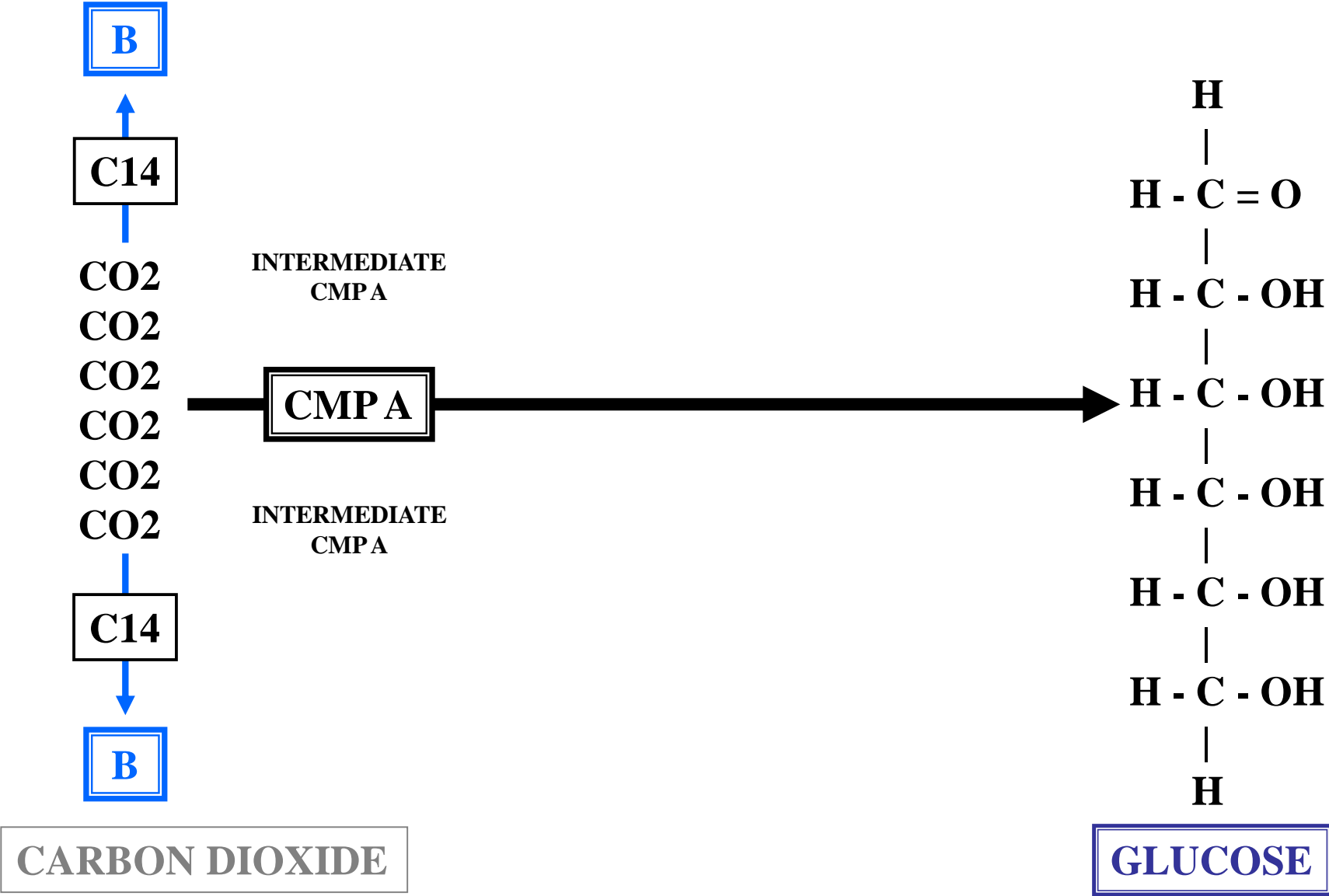


1 MINUTE

PHOTOSYNTHESIS

GREEN ALGAE

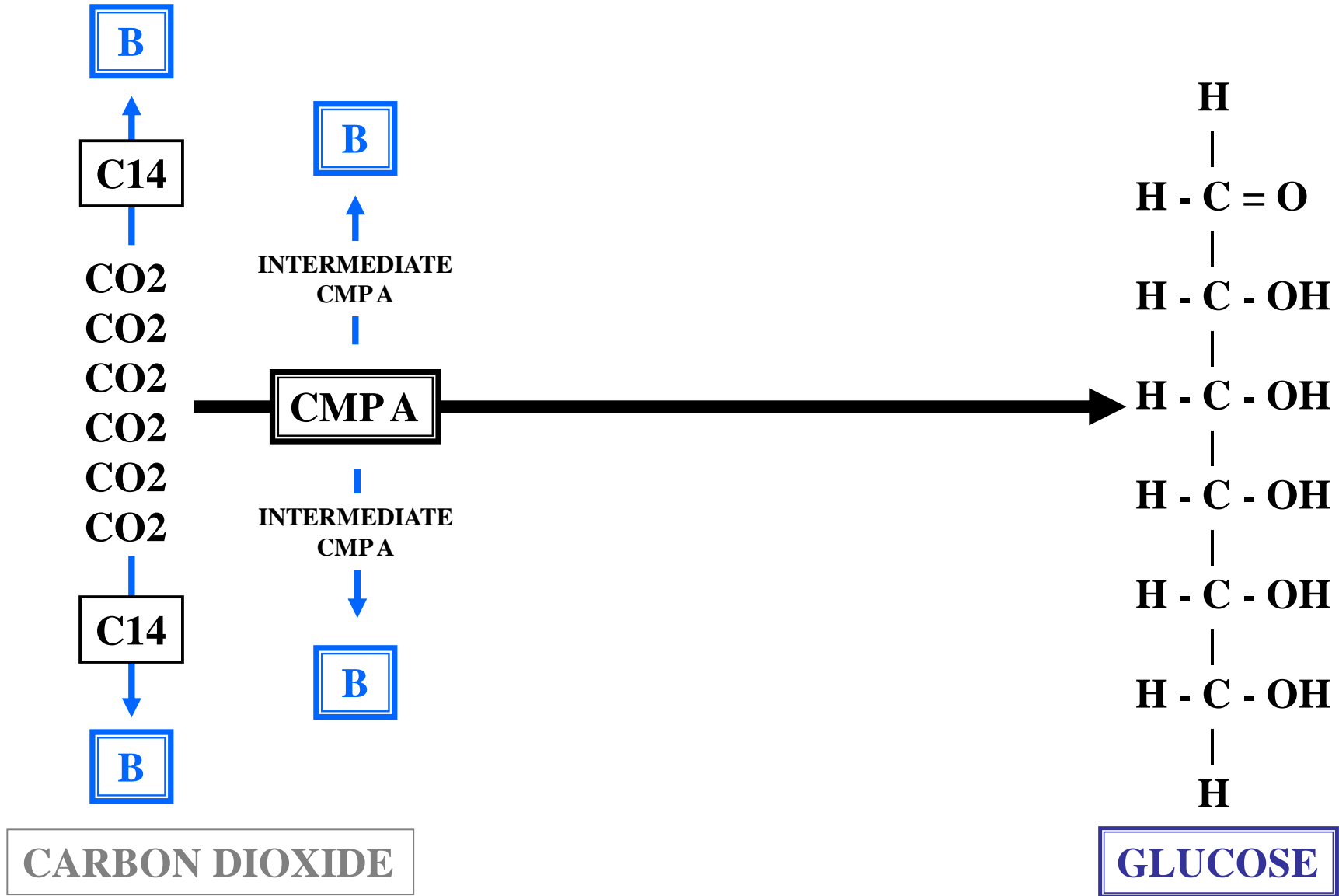
C14: BIOCHEMICAL TRACER



B = BETA PARTICLE

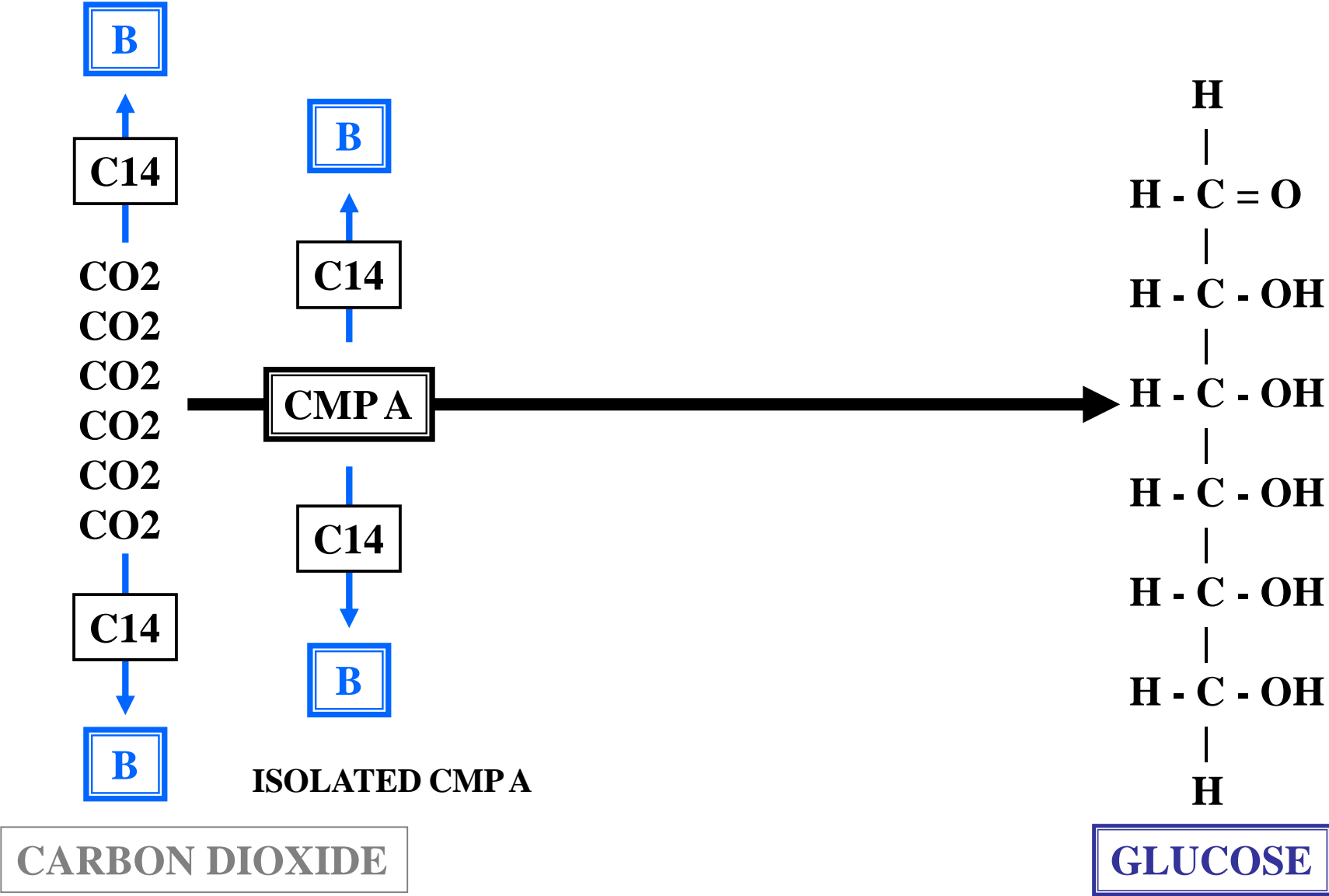
C14: BIOCHEMICAL TRACER

C14



B = BETA PARTICLE

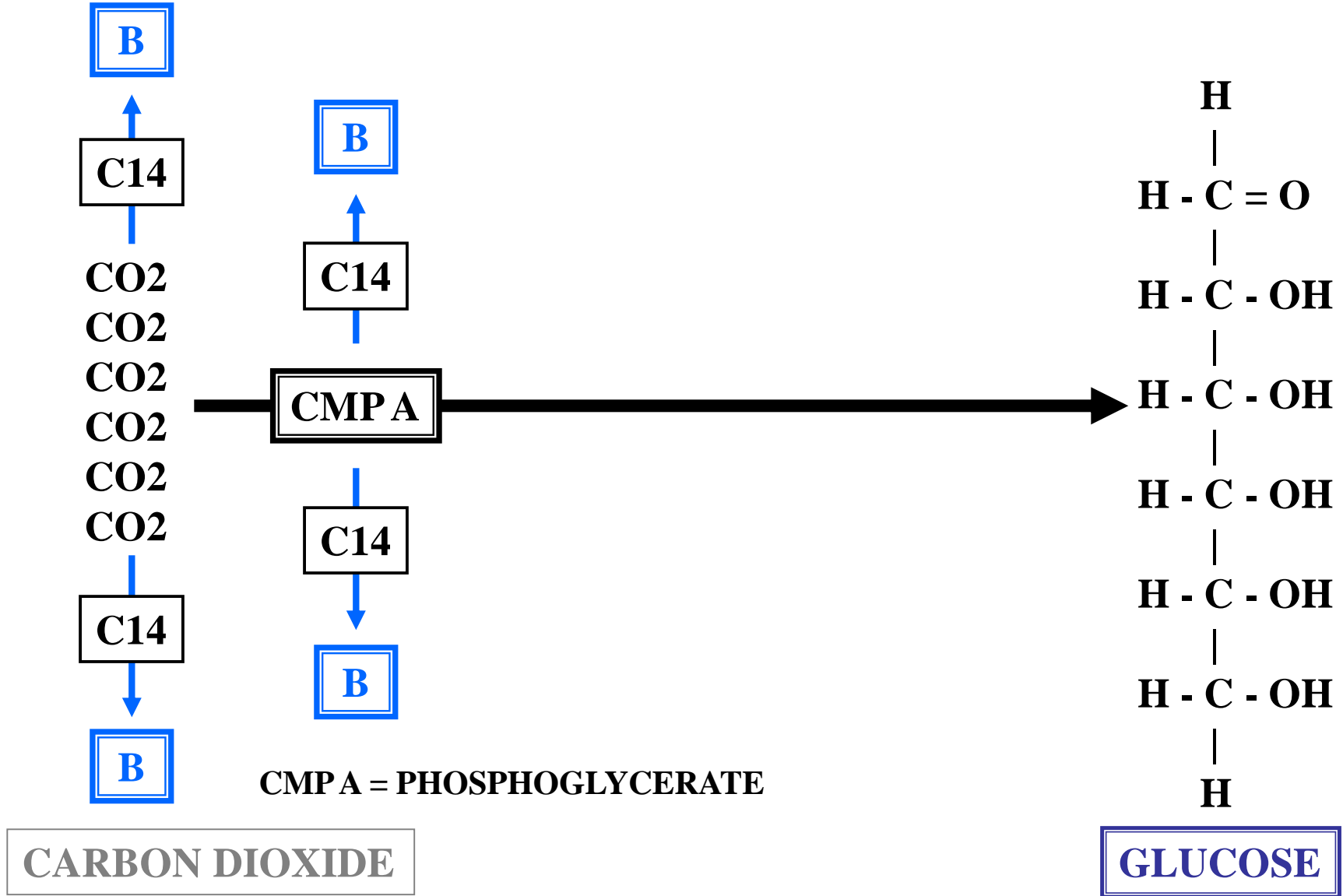
C14: BIOCHEMICAL TRACER



B = BETA PARTICLE

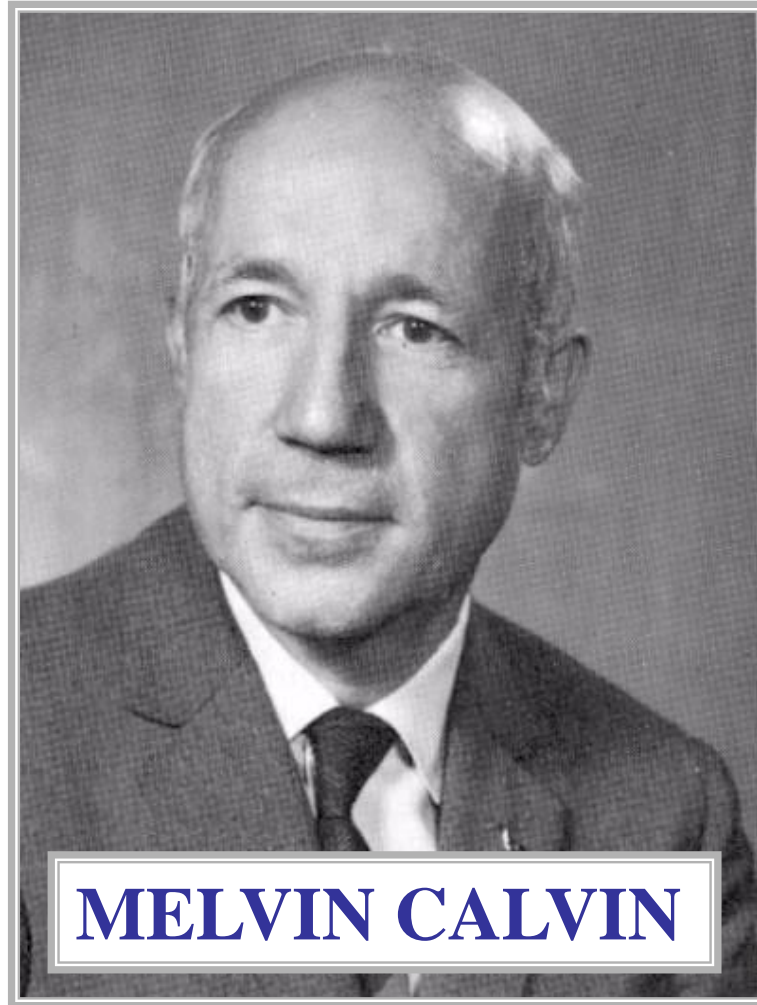


C14: BIOCHEMICAL TRACER



B = BETA PARTICLE

C14: BIOCHEMICAL TRACER



**PLANT PHYSIOLOGIST
UTILIZED C14 ISOTOPES**



PHOTOSYNTHESIS

GREEN ALGAE

B

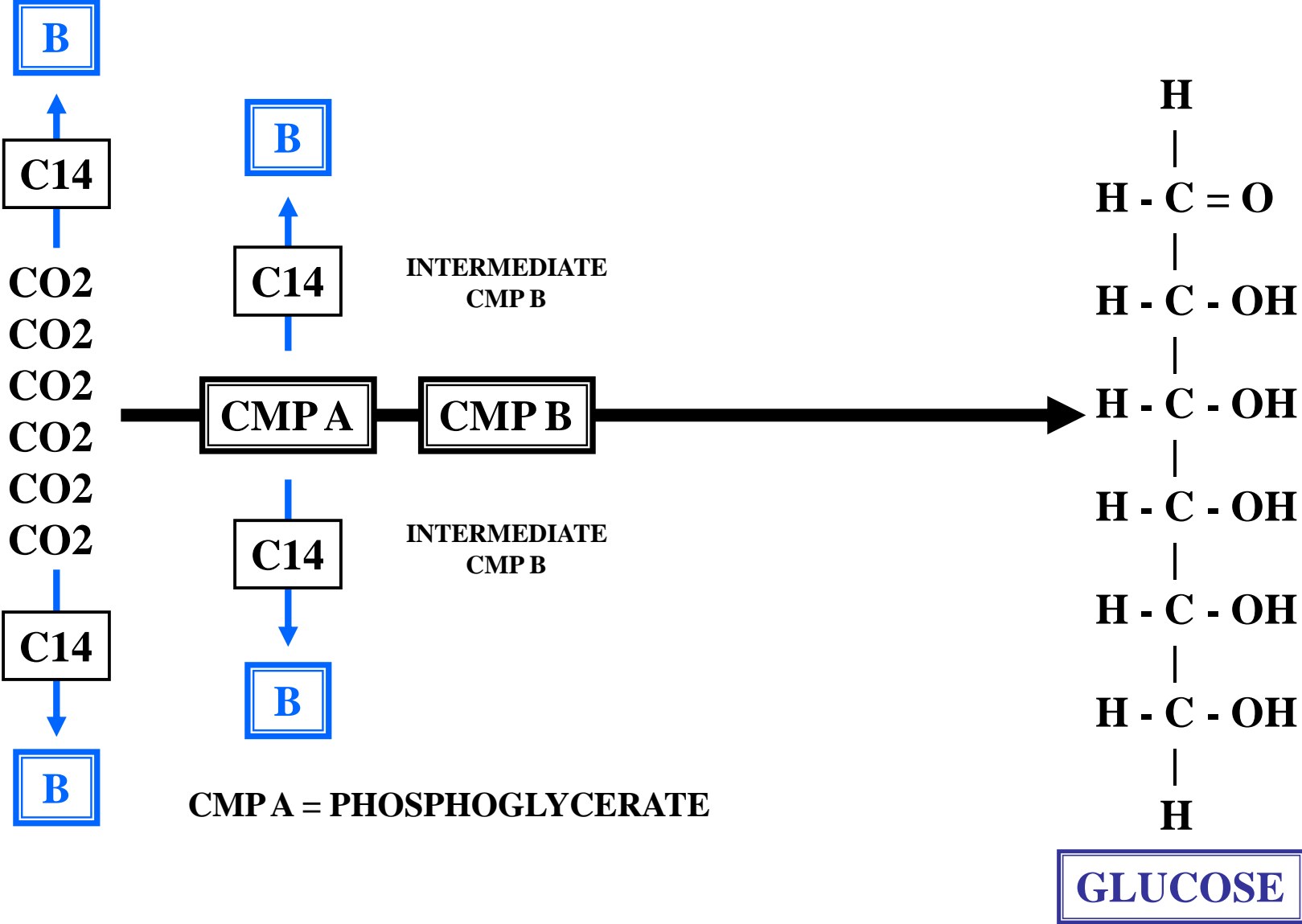
2 MINUTES

PHOTOSYNTHESIS

GREEN ALGAE



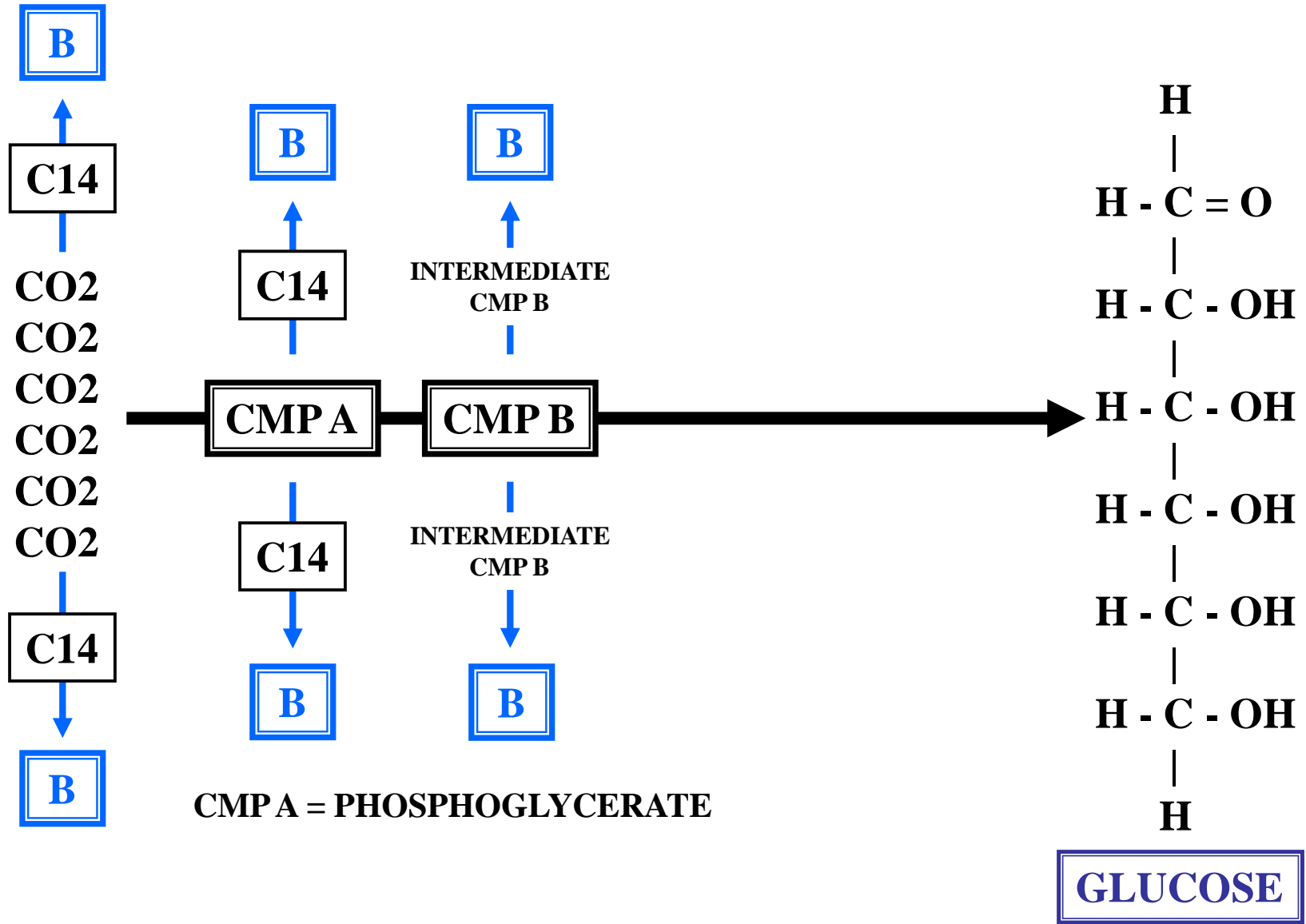
C14: BIOCHEMICAL TRACER



CMP A = PHOSPHOGLYCERATE

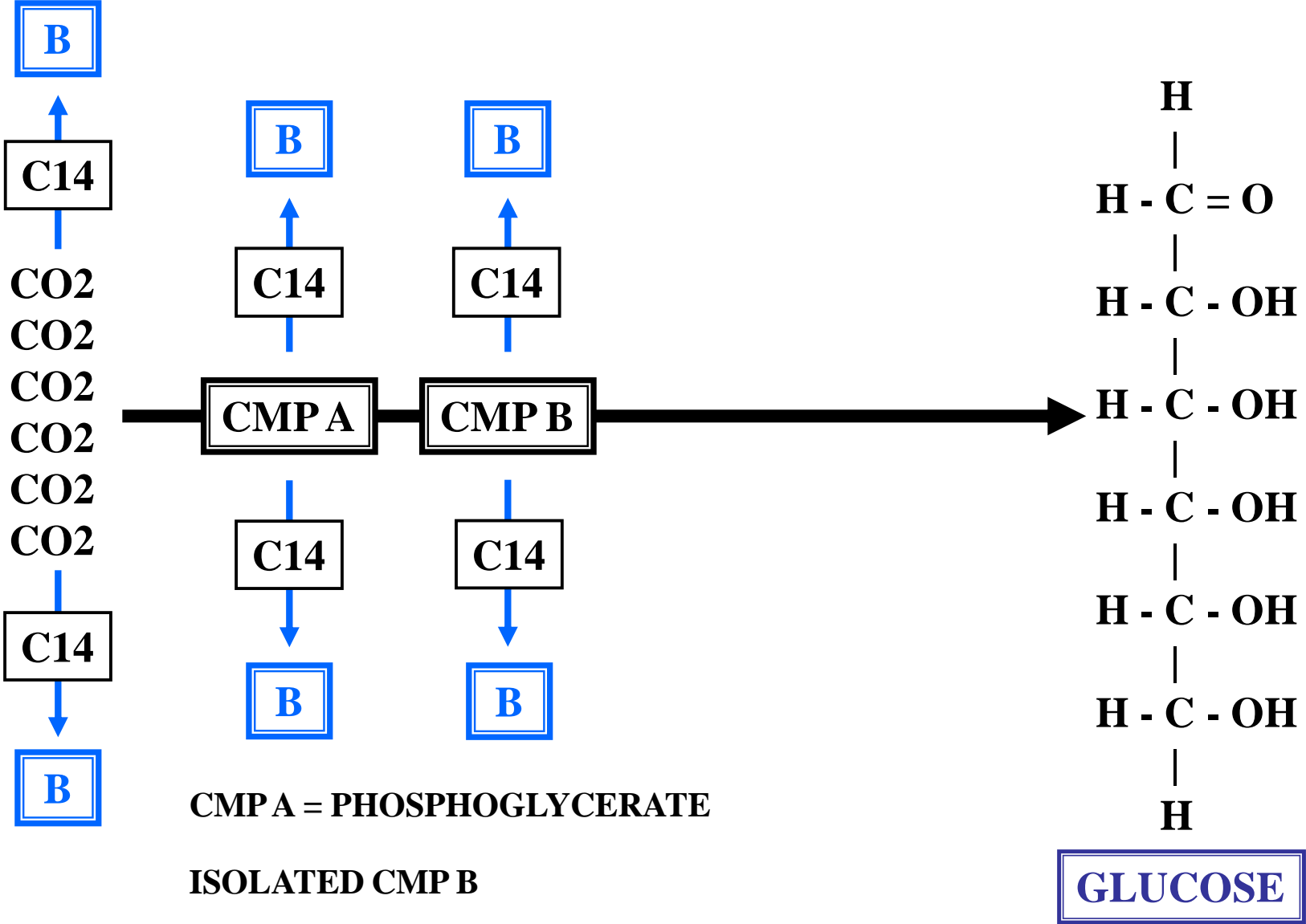
GLUCOSE

C14: BIOCHEMICAL TRACER



B = BETA PARTICLE

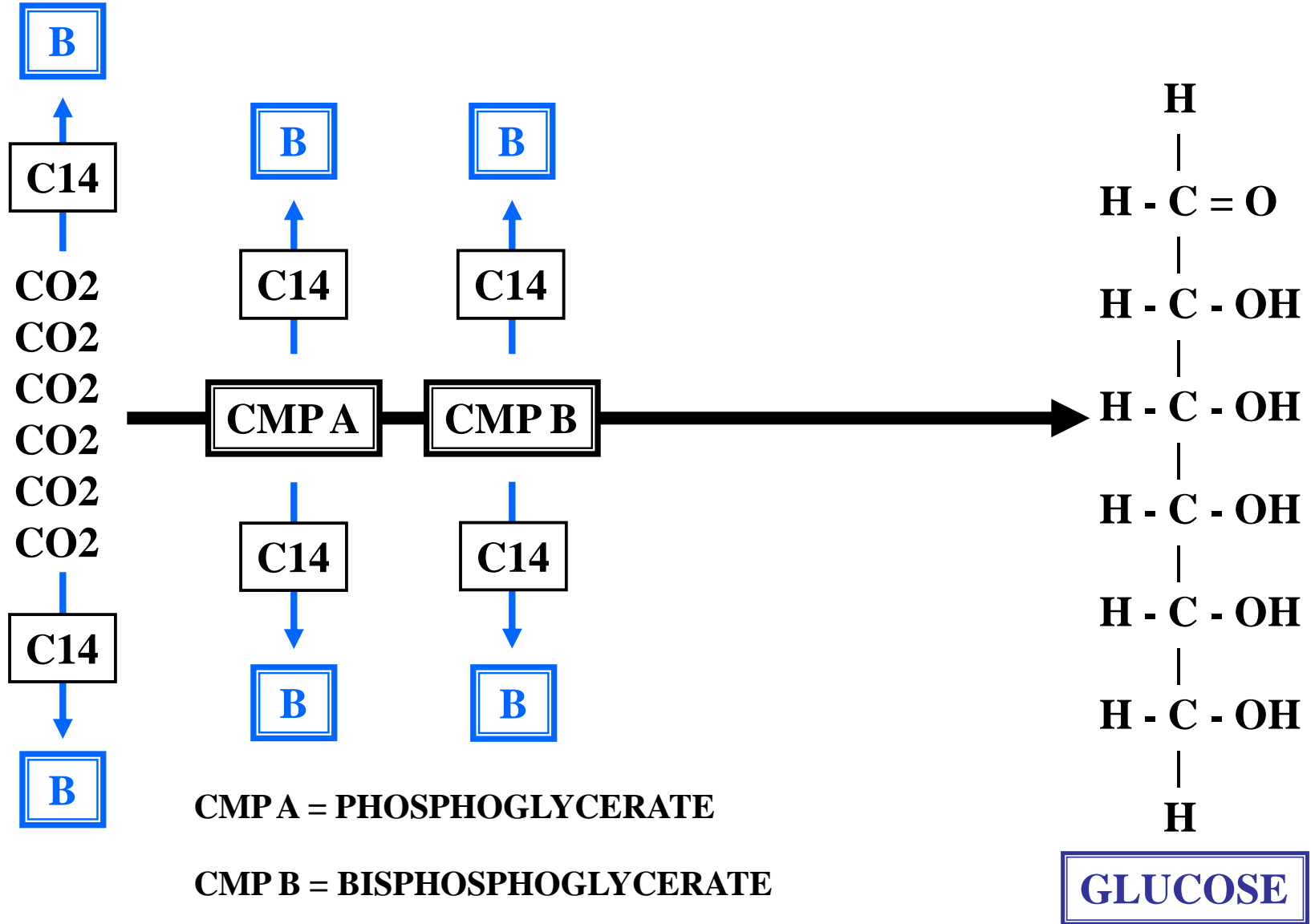
C14: BIOCHEMICAL TRACER



B = BETA PARTICLE

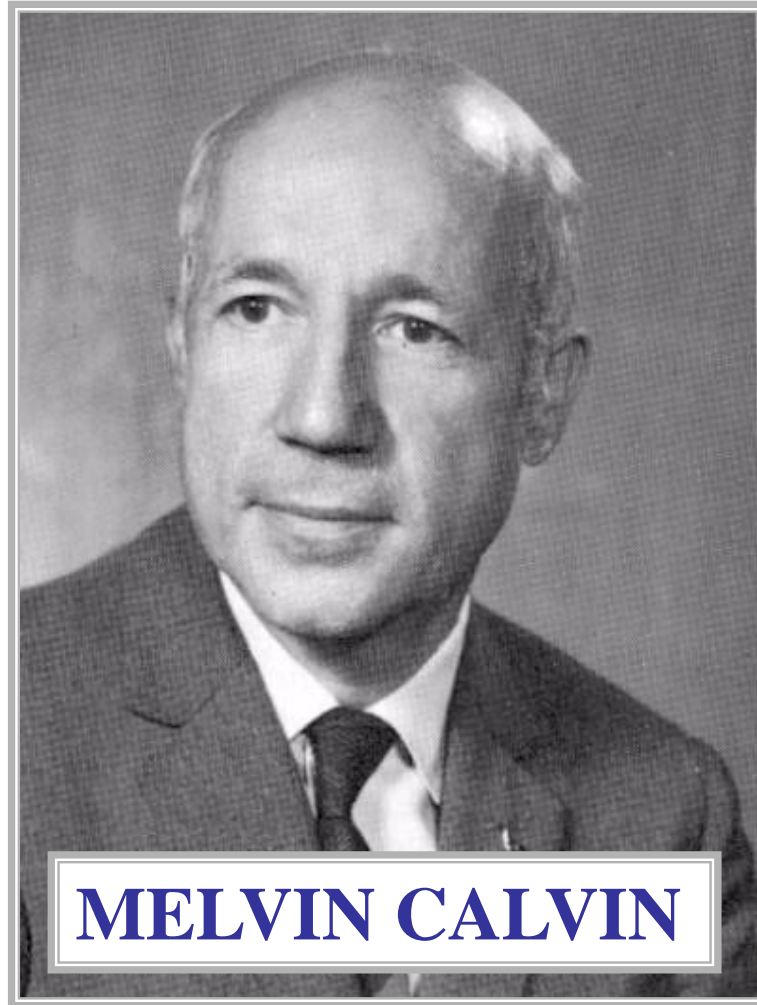


C14: BIOCHEMICAL TRACER



B = BETA PARTICLE

C14: BIOCHEMICAL TRACER



**PLANT PHYSIOLOGIST
UTILIZED C14 ISOTOPES**



PHOTOSYNTHESIS

GREEN ALGAE

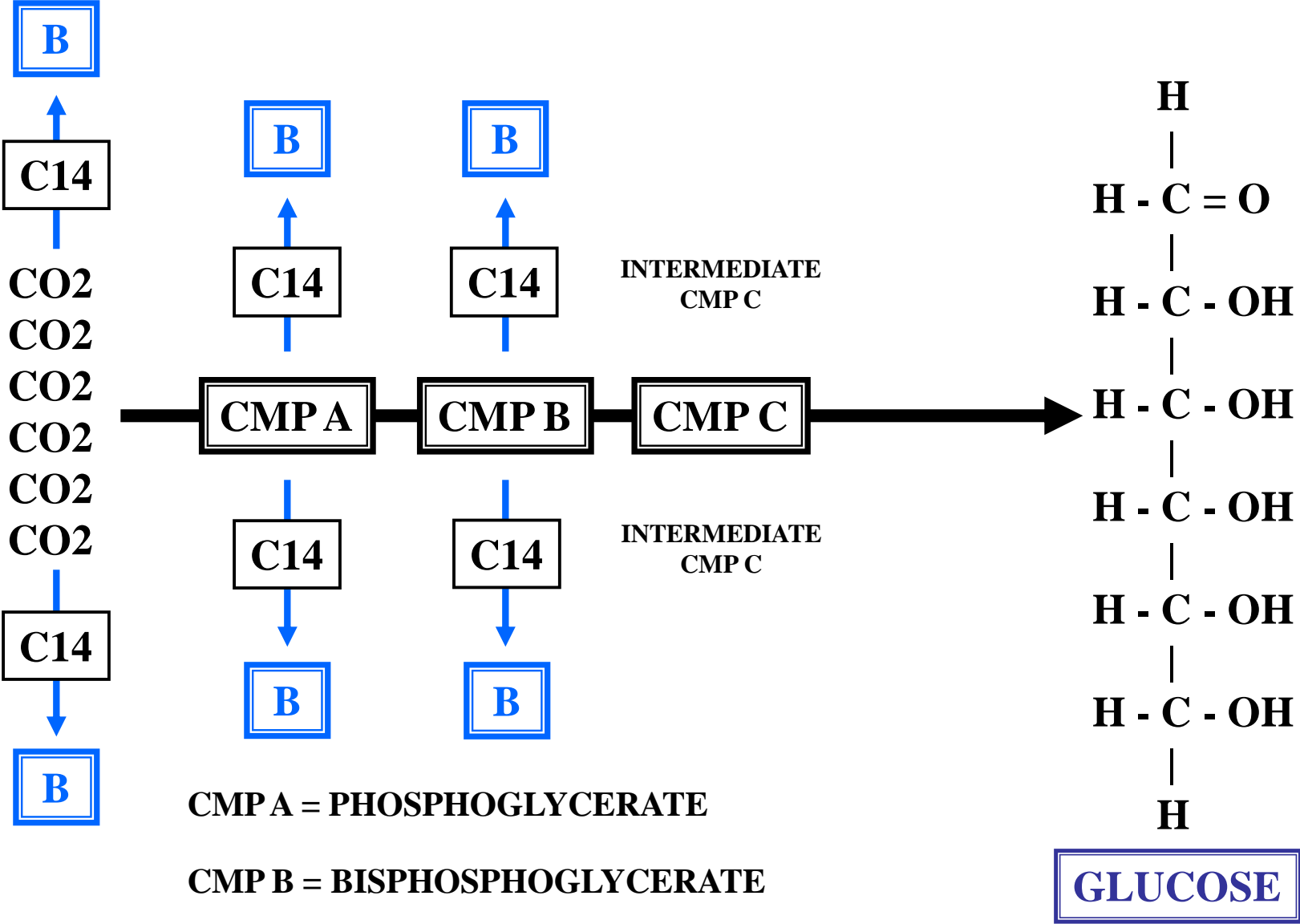


3 MINUTES

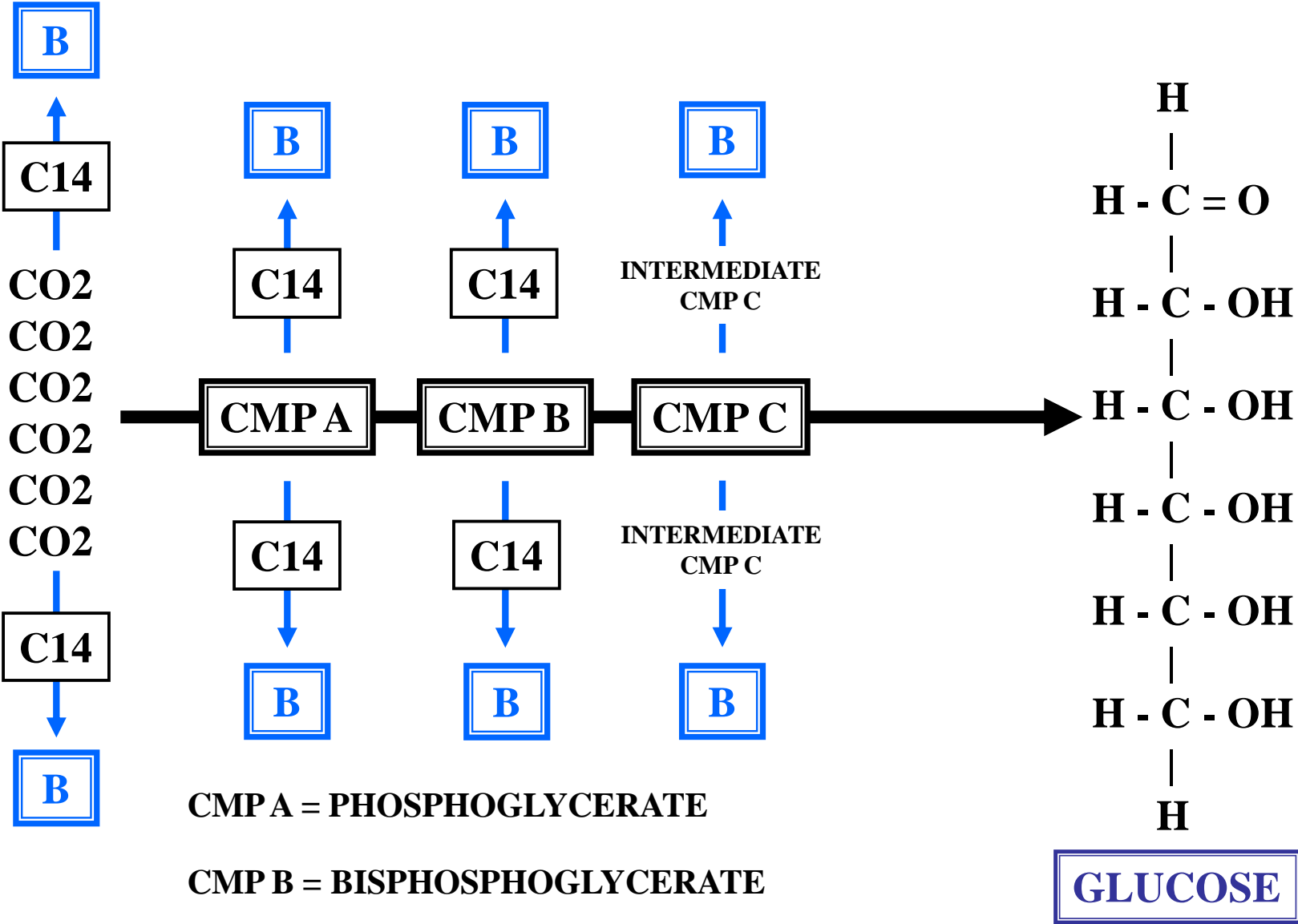
PHOTOSYNTHESIS

GREEN ALGAE

C14: BIOCHEMICAL TRACER



C14: BIOCHEMICAL TRACER



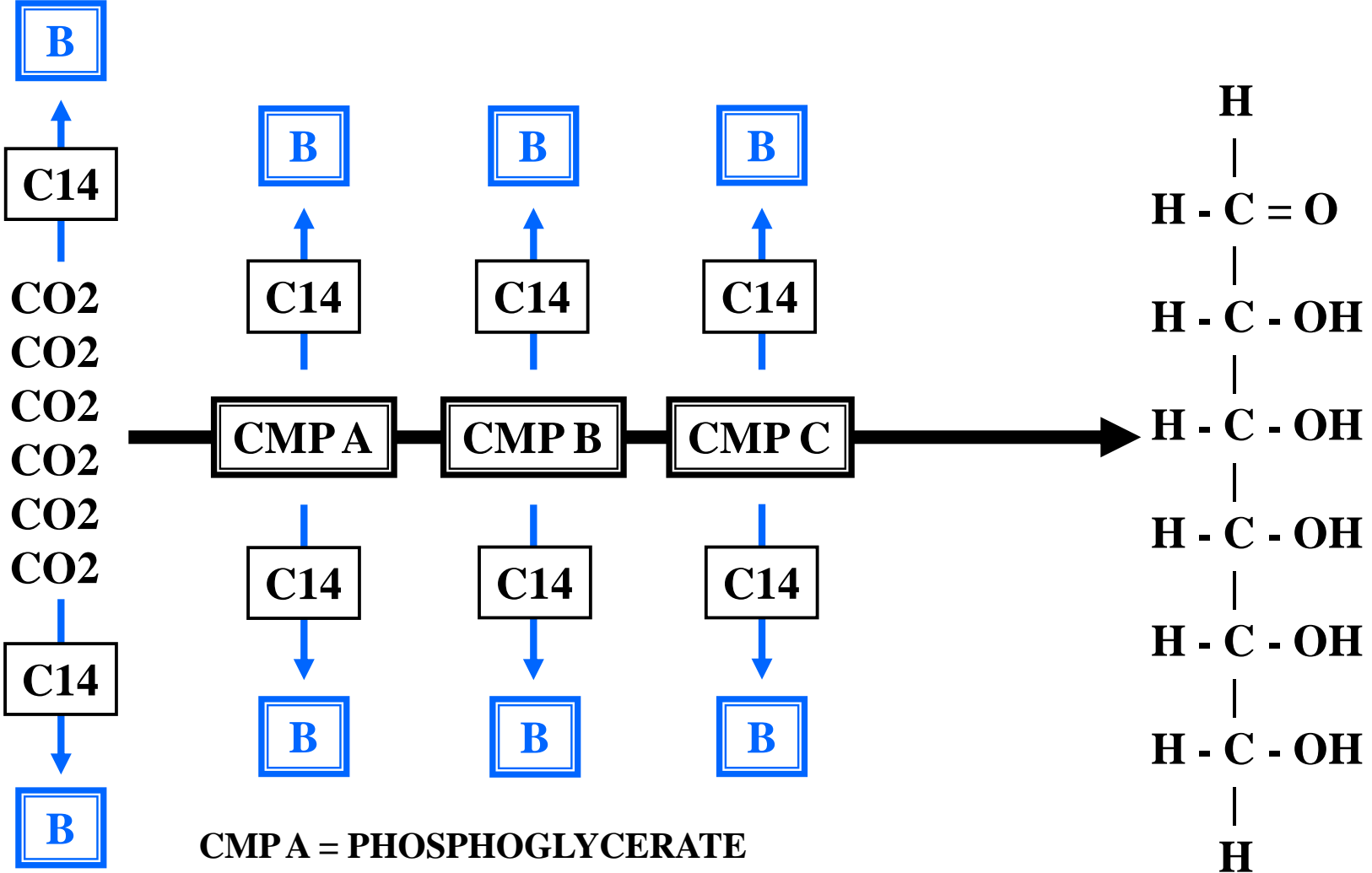
CMP A = PHOSPHOGLYCERATE

CMP B = BISPHOSPHOGLYCERATE

GLUCOSE

B = BETA PARTICLE

C14: BIOCHEMICAL TRACER



CMP A = PHOSPHOGLYCERATE

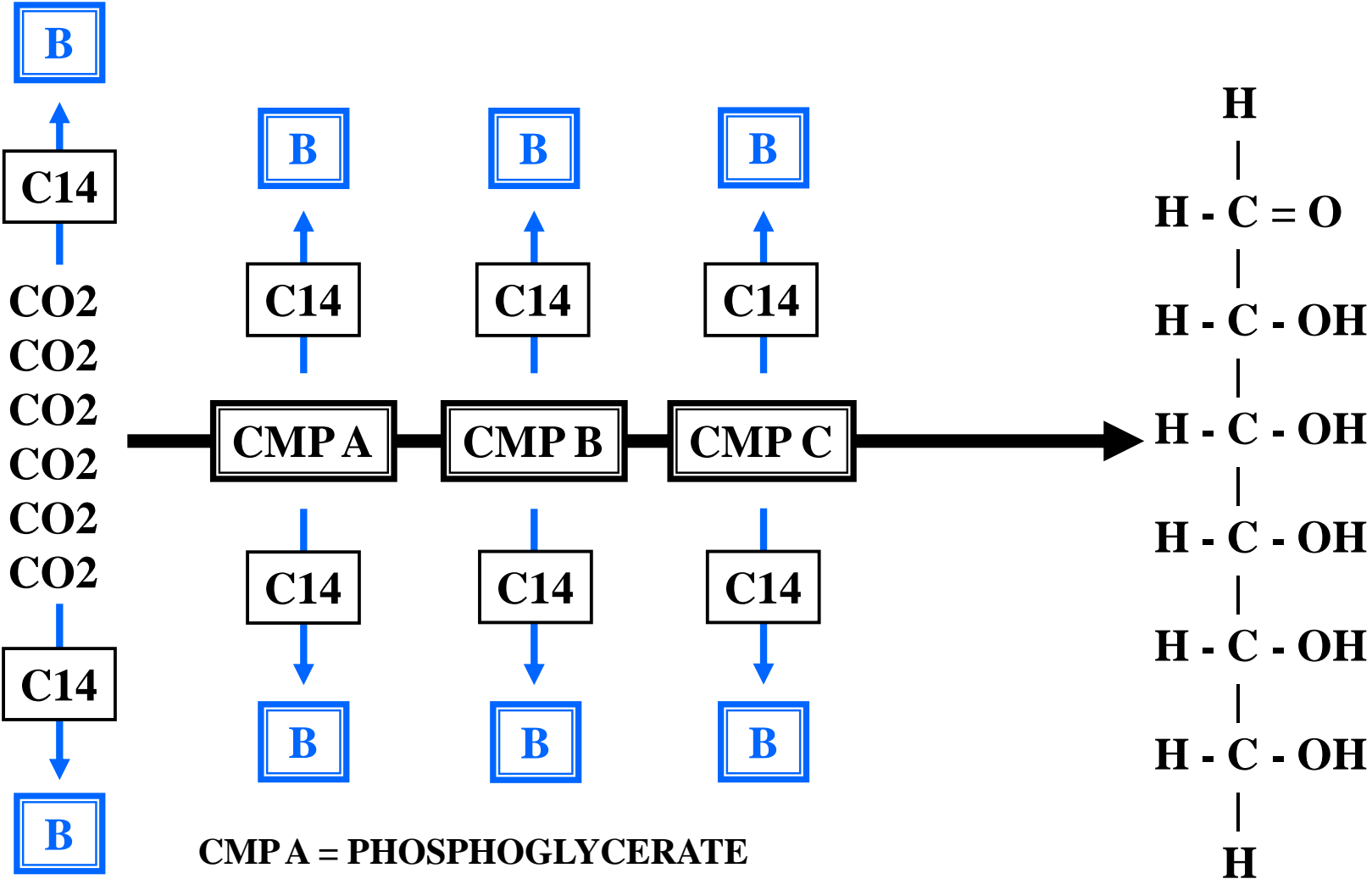
CMP B = BISPHOSPHOGLYCERATE

ISOLATED CMP C

B = BETA PARTICLE

GLUCOSE

C14: BIOCHEMICAL TRACER



CMP A = PHOSPHOGLYCERATE

CMP B = BISPHOSPHOGLYCERATE

CMP C = PHOSPHOGLYCERALDEHYDE

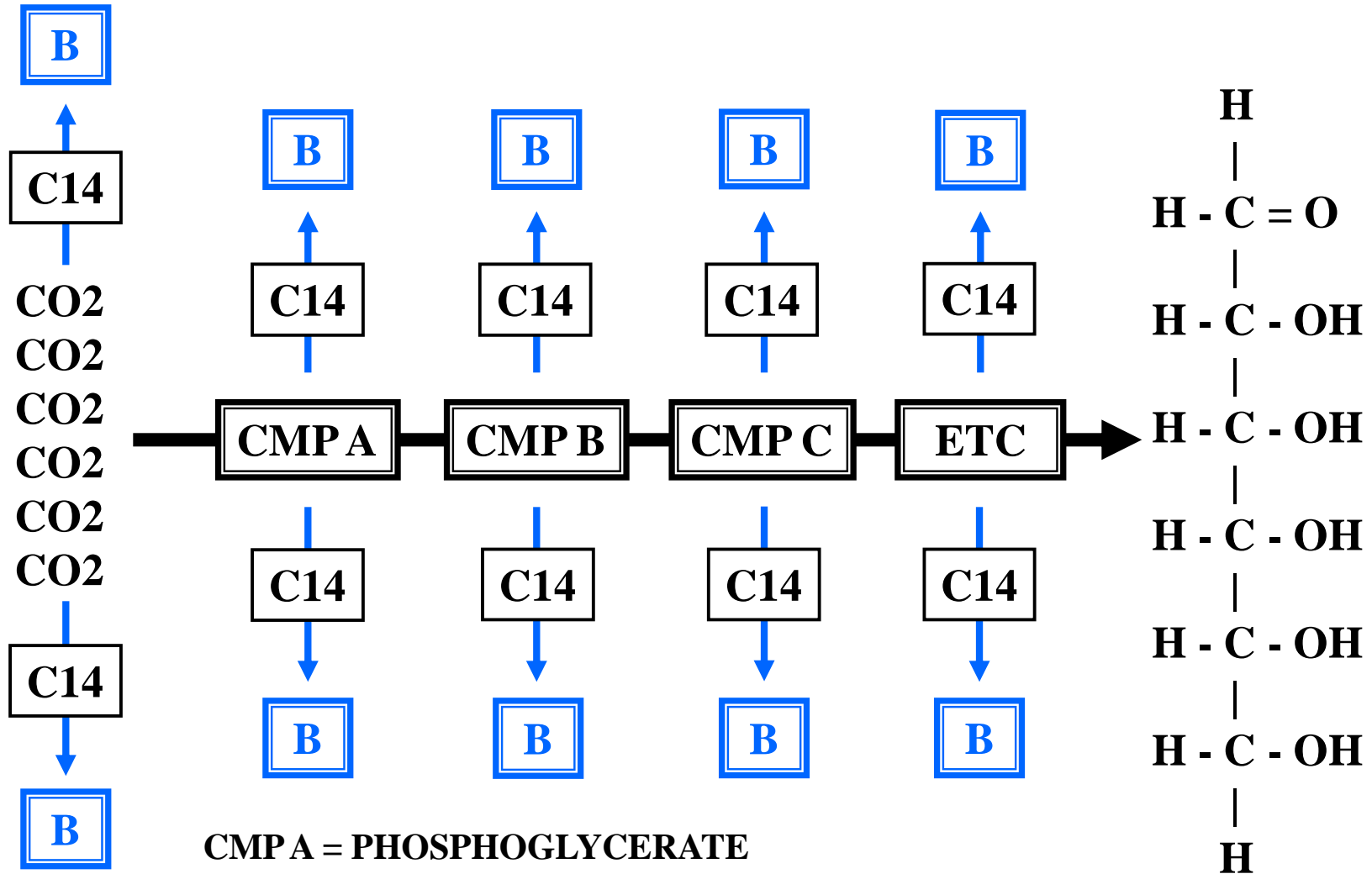
GLUCOSE

B = BETA PARTICLE

C14: BIOCHEMICAL TRACER



B



CMP A = PHOSPHOGLYCERATE

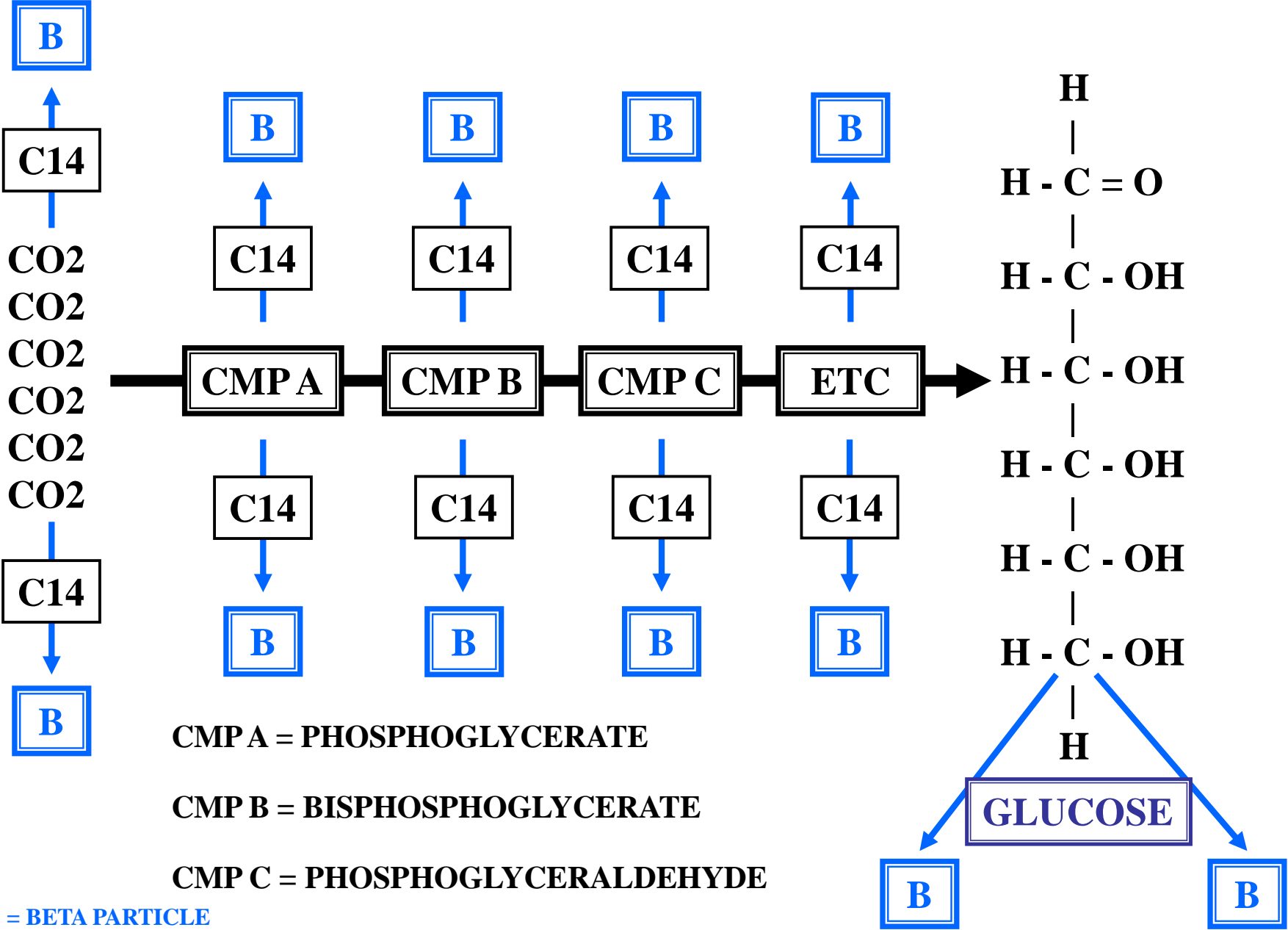
CMP B = BISPHOSPHOGLYCERATE

CMP C = PHOSPHOGLYCERALDEHYDE

GLUCOSE

B = BETA PARTICLE

C14: BIOCHEMICAL TRACER



C14

CO₂ + RIBULOSE BISPHOSPHATE / (RUBP)

**RIBULOSE BISPHOSPHATE
CARBOXYLASE
(RUBP-CARBOXYLASE)**

UNSTABLE C6 INTERMEDIATE

PHOSPHOGLYCERATE / (PGA)

PHOSPHOGLYCERATE / (PGA)

ATP

ATP

BISPHOGLYCERATE / (BIPGA)

BISPHOGLYCERATE / (BIPGA)

NADPH

NADPH

PHOSPHOGLYCERALDEHYDE / (PGAL)

PHOSPHOGLYCERALDEHYDE / (PGAL)

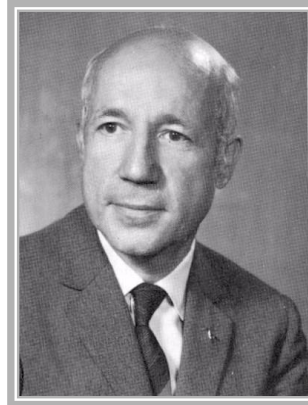
**COMPLEX SERIES
CHEMICAL RXTS
(CSCR)**

**COMPLEX SERIES
CHEMICAL RXTS
(CSCR)**

GLUCOSE

**DARK REACTION
CALVIN CYCLE
OF
PHOTOSYNTHESIS**

RIBULOSE BISPHOSPHATE / (RUBP)





\$

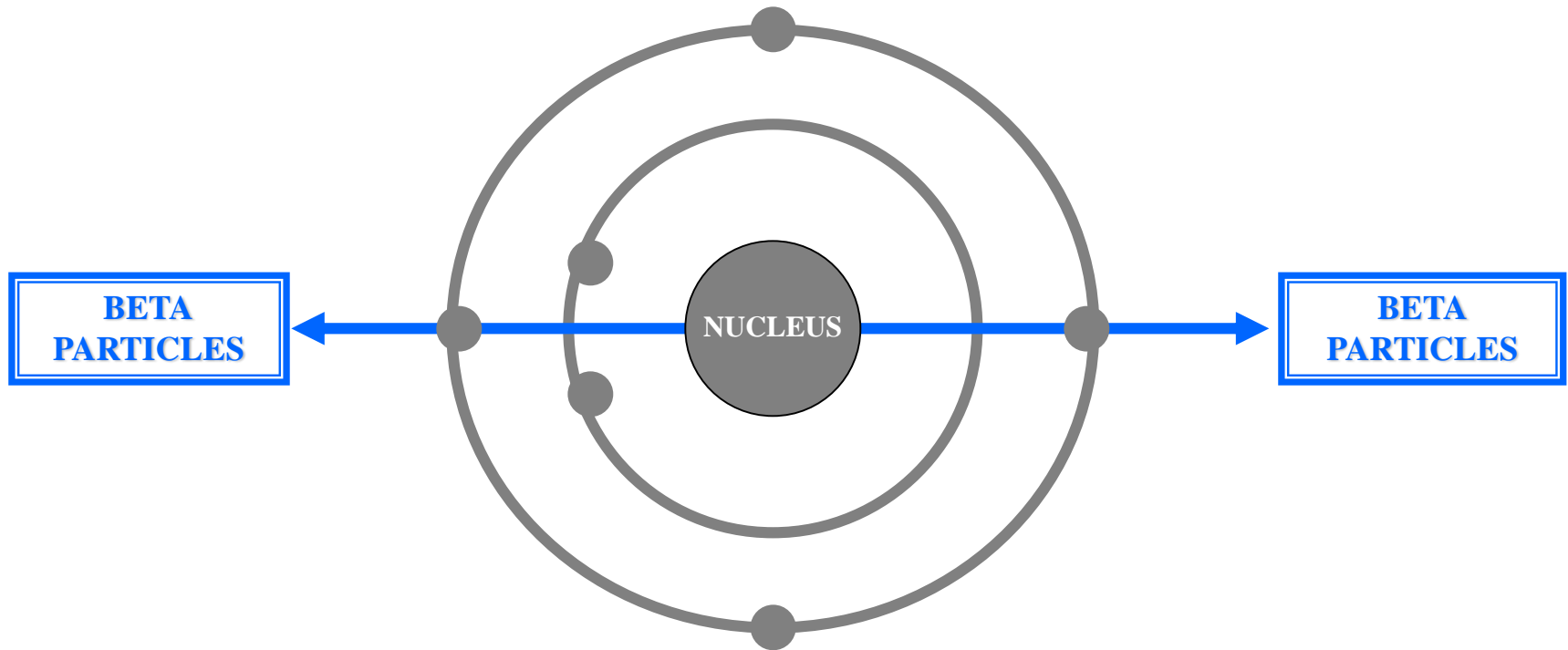
C14

MELVIN CALVIN

SCIENCE NOBLE PRIZE

RADIOACTIVE C14

USEFUL BIOLOGICAL TOOL

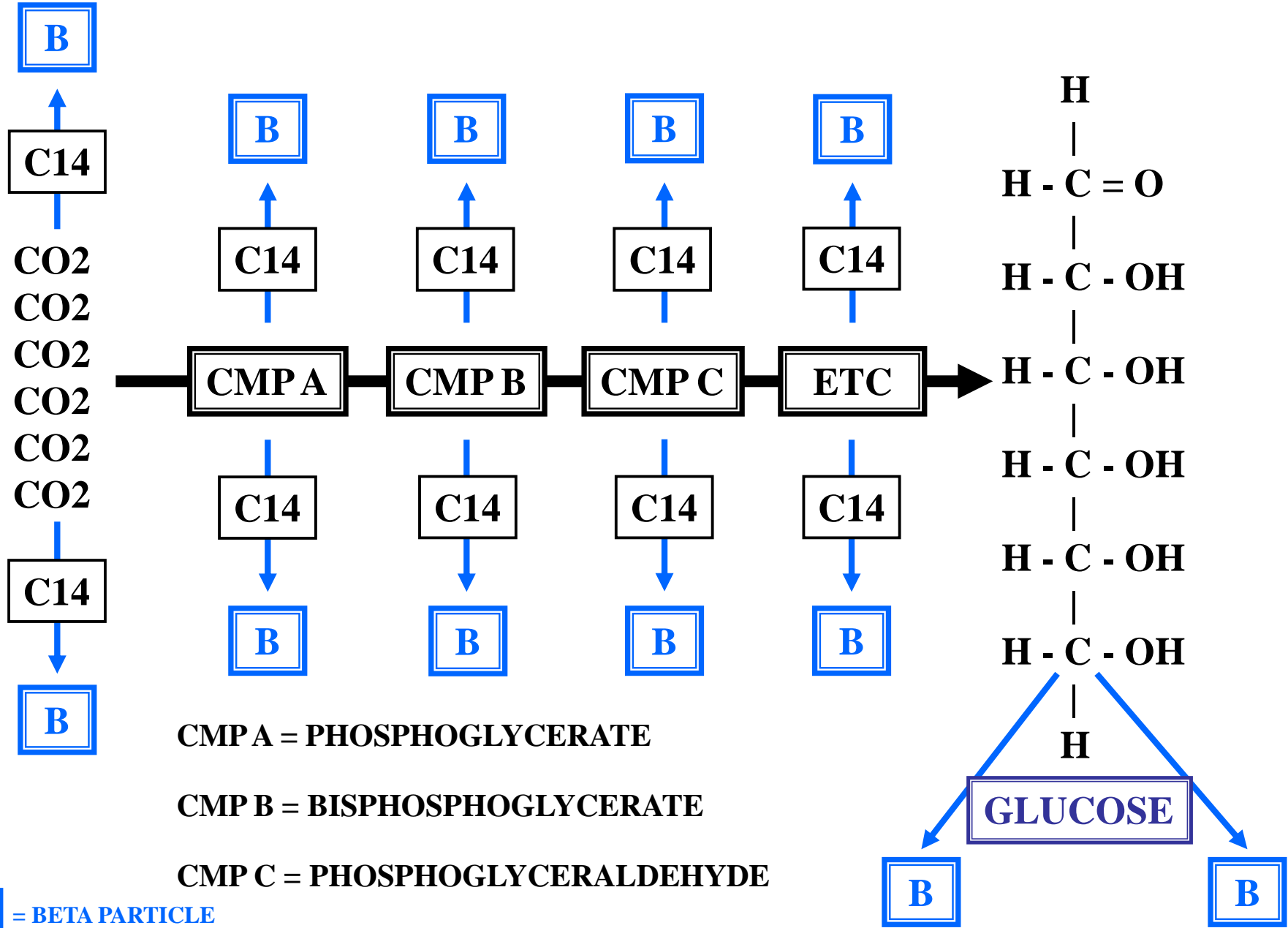


EMITS **BETA** PARTICLES

C14

● = e-

C14: BIOCHEMICAL TRACER



PHOTOSYNTHESIS

R



WATER

CO₂

LIGHT ENERGY

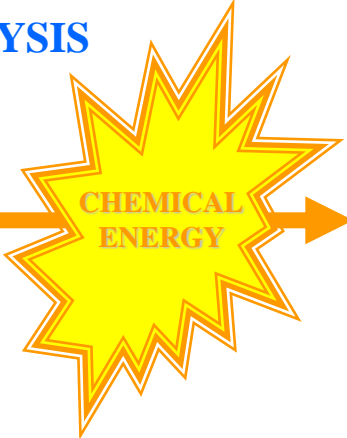
PHOTO

ATMOSPHERE

E- PHOTOLYSIS



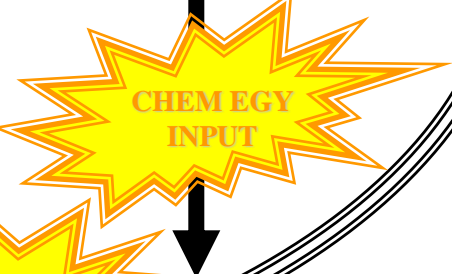
LT RXT
THYLAKOID



DK RXT
STROMA

CHLOROPLAST

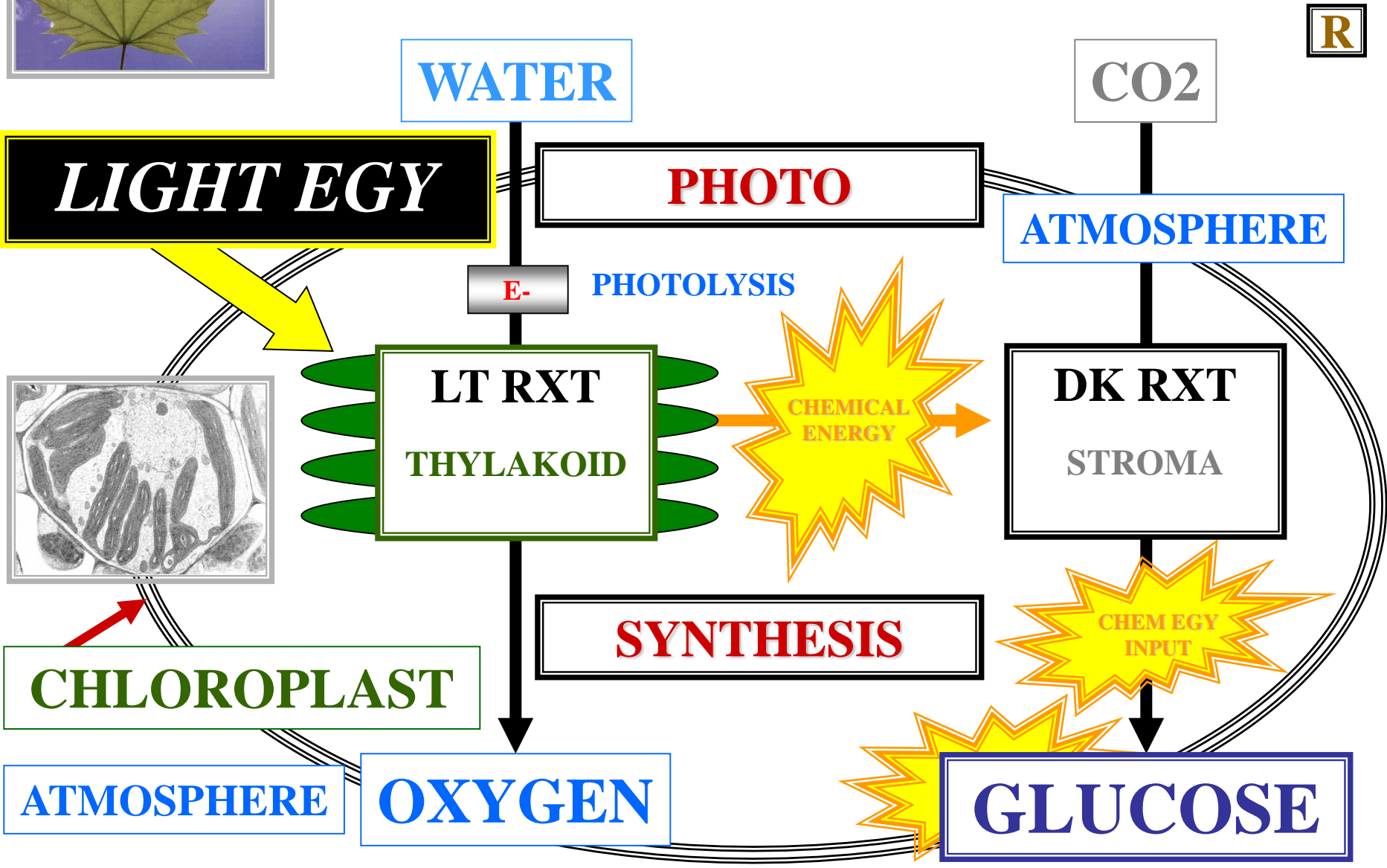
SYNTHESIS



ATMOSPHERE

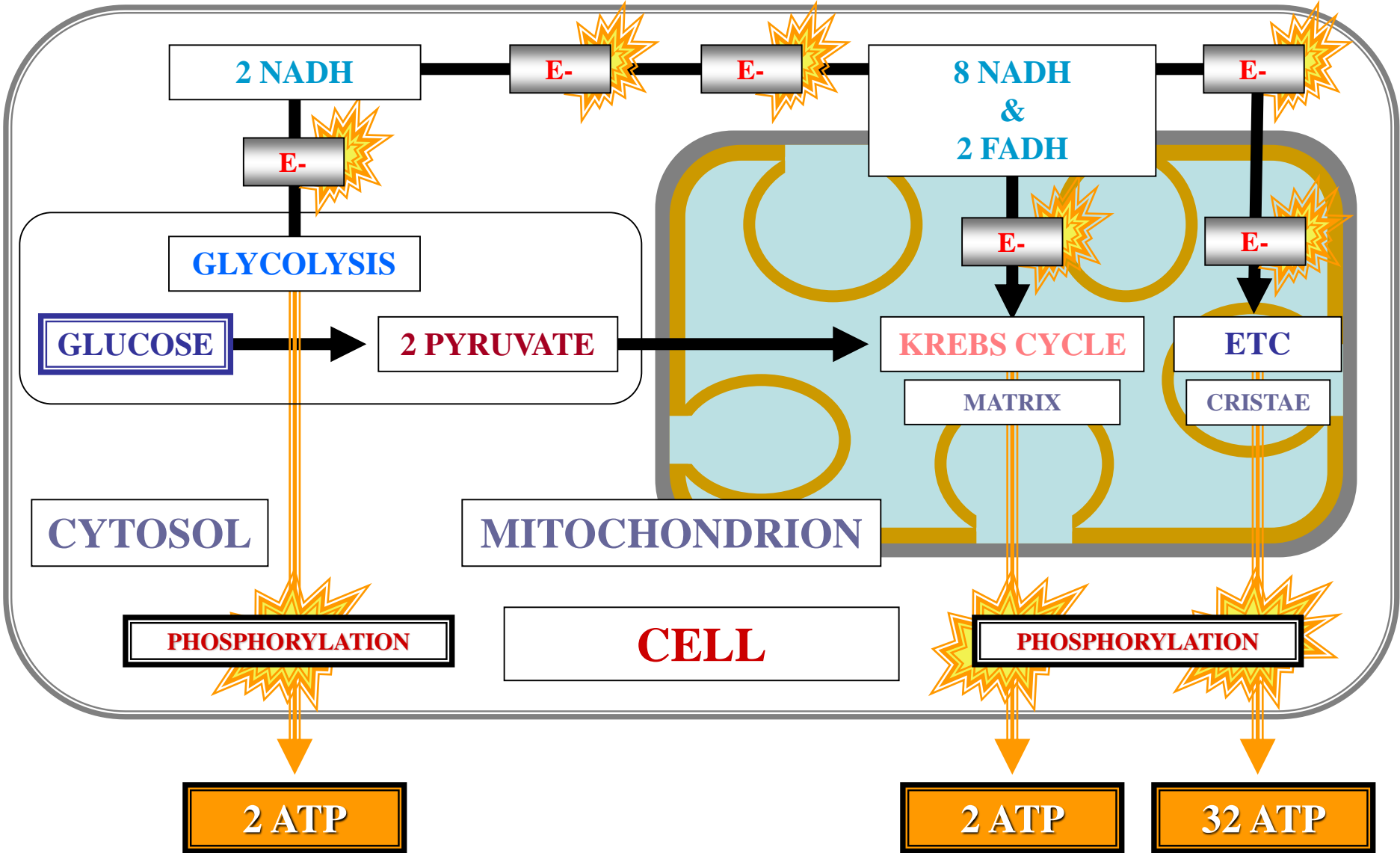
OXYGEN

GLUCOSE





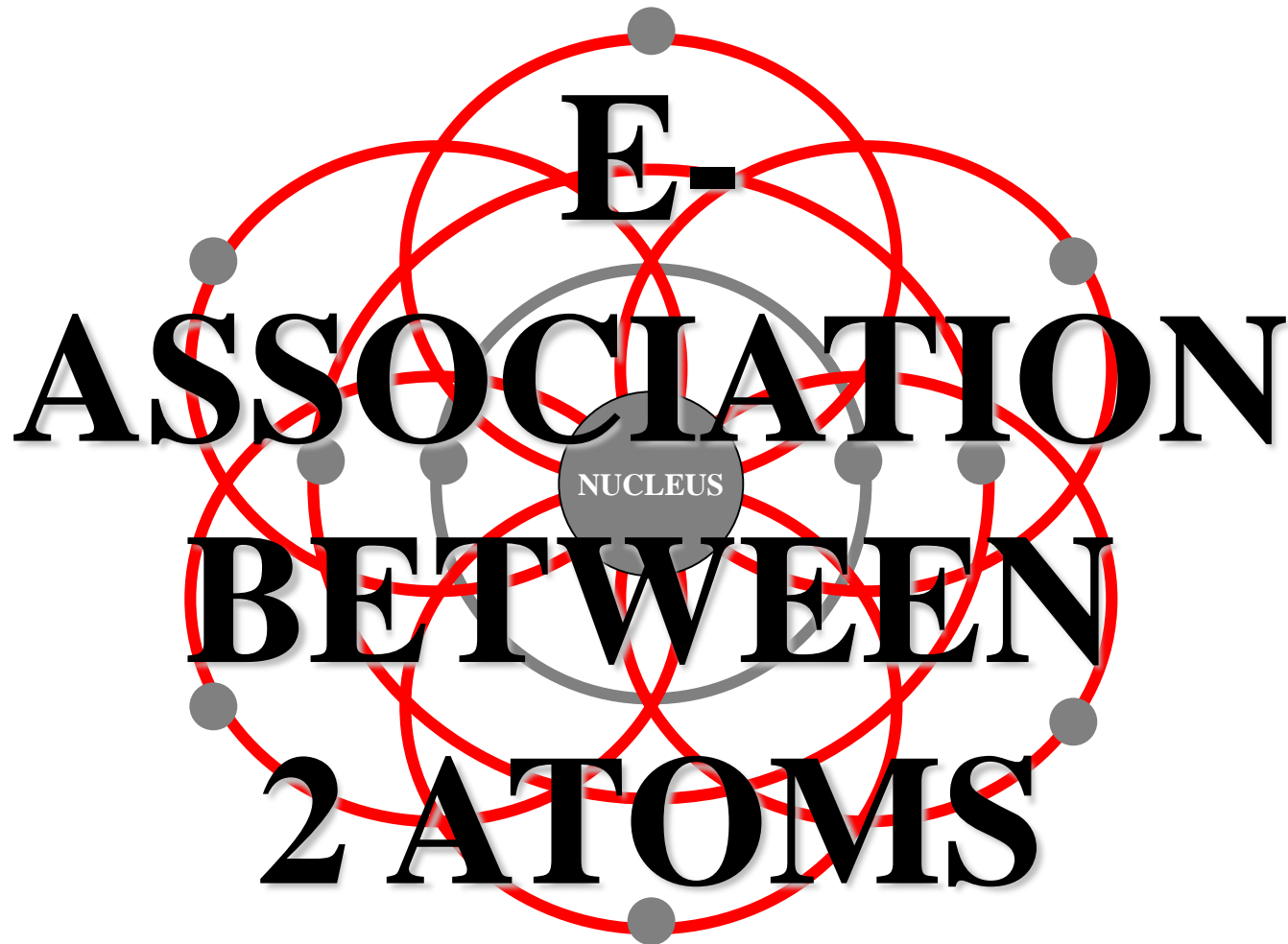
RESPIRATION



CHEMICAL BONDS BETWEEN ATOMS

CHEMICAL BOND

CHEMICAL BOND



CHEMICAL BOND

CHEMICAL BOND



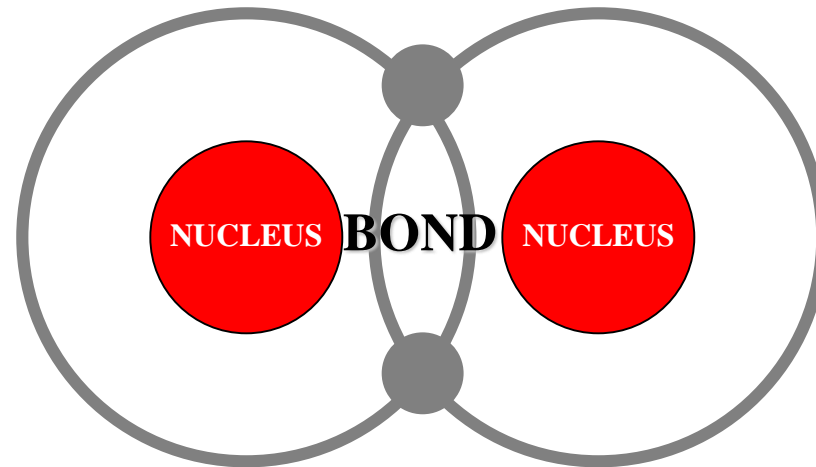
HYDROGEN ATOMS

● = e-

CHEMICAL BOND



BONDED HYDROGEN ATOMS



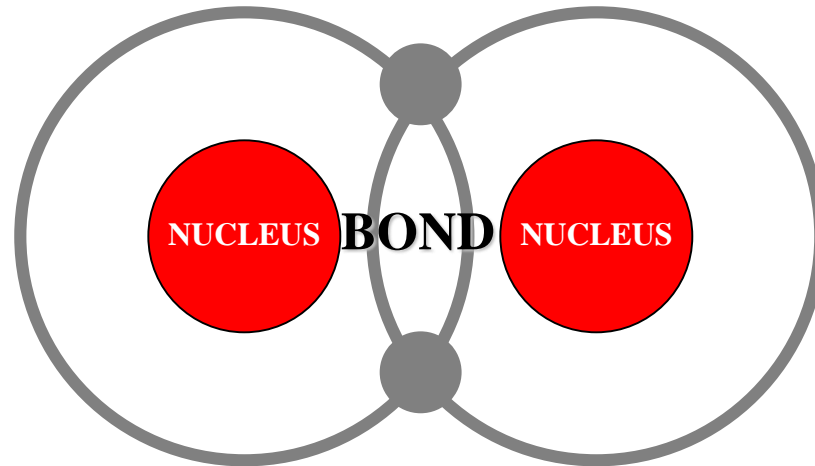
● = E-

E- ASSOCIATION BETWEEN 2 ATOMS

CHEMICAL BOND



BONDED HYDROGEN ATOMS



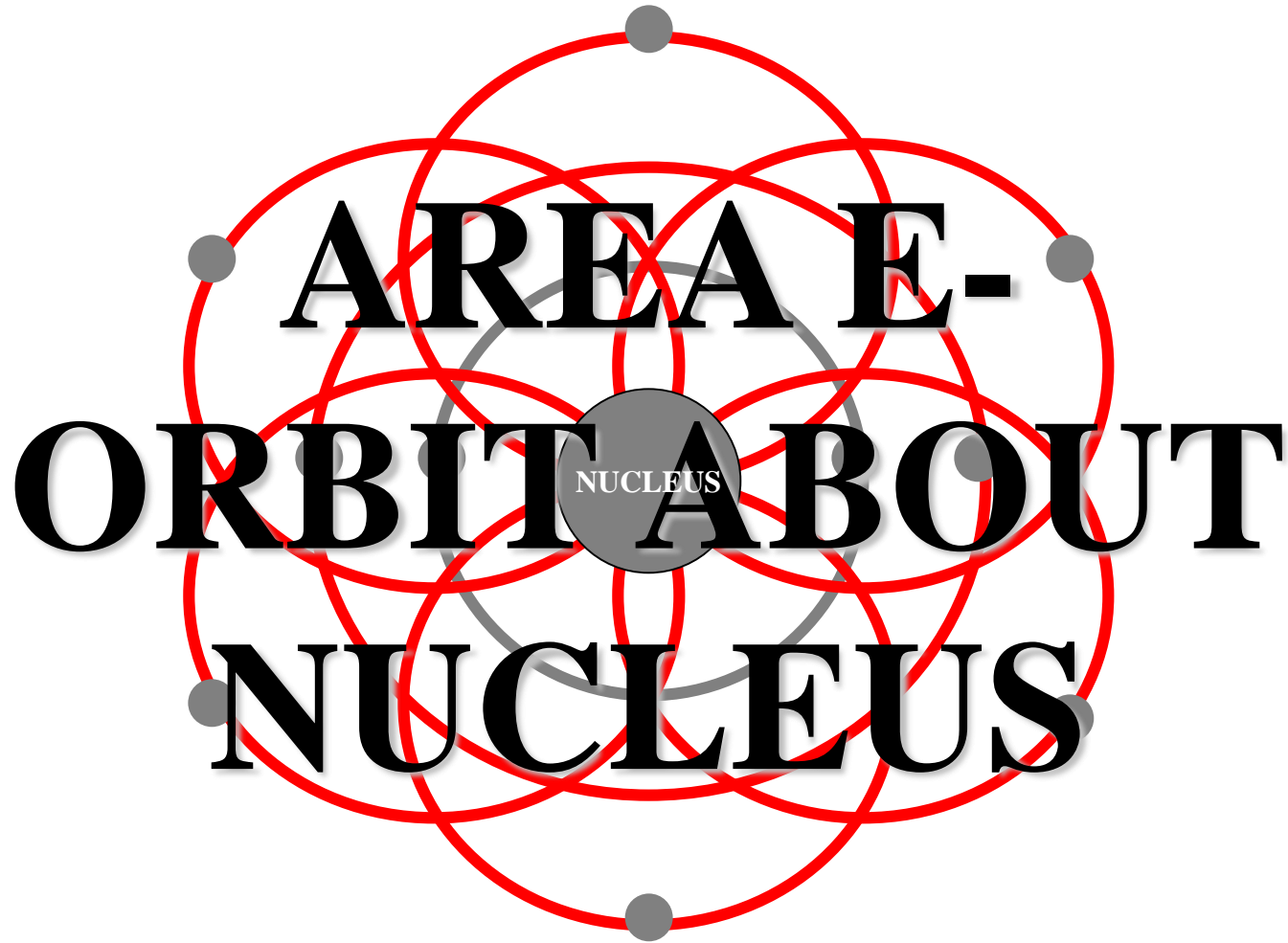
● = E-

E- SURROUND NUCLEUS W/IN ORBITALS & ENERGY SHELLS

ORBITALS
VS
ENERGY SHELLS

ORBITAL

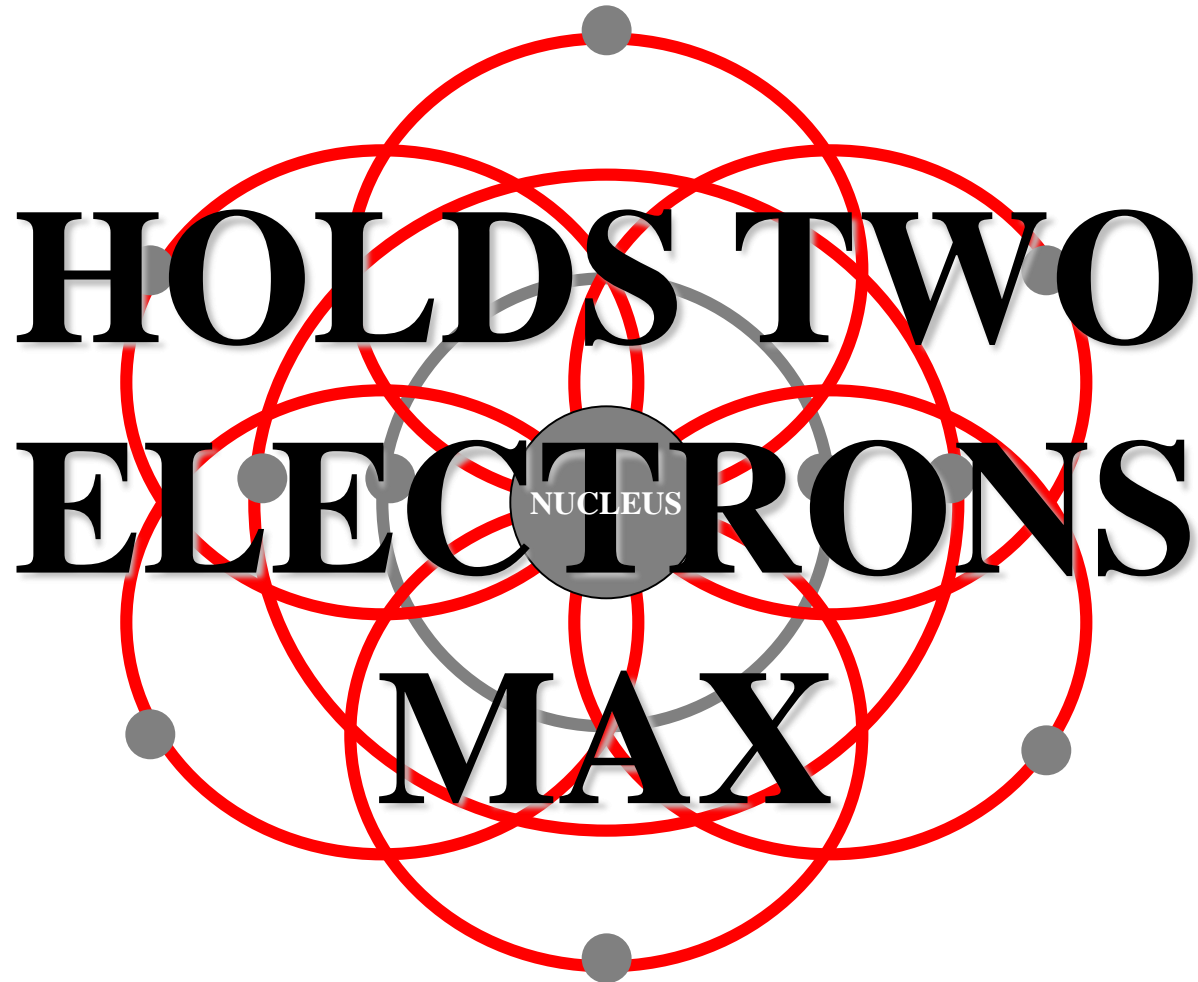
ORBITAL



ORBITAL

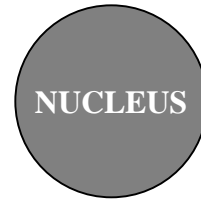


ORBITAL



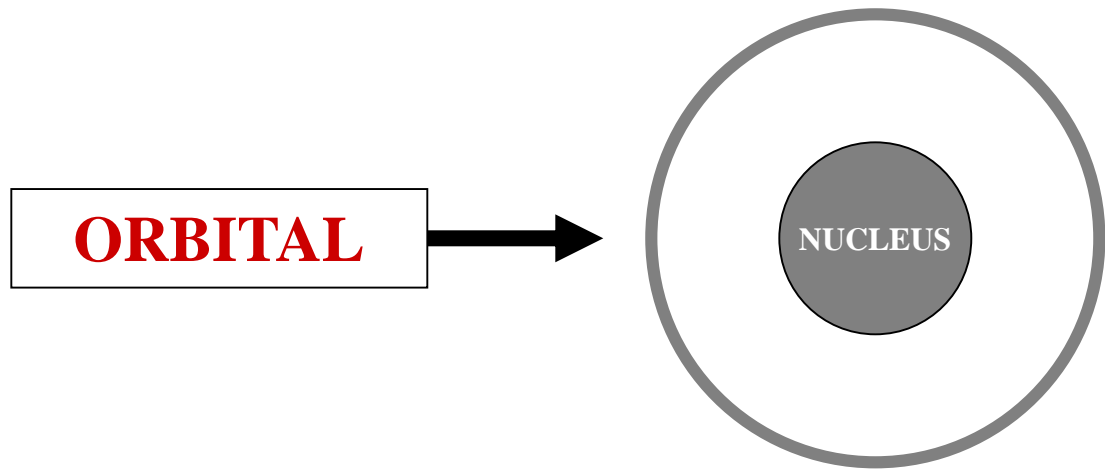
ORBITAL

E- ORBITALS & ENERGY SHELLS



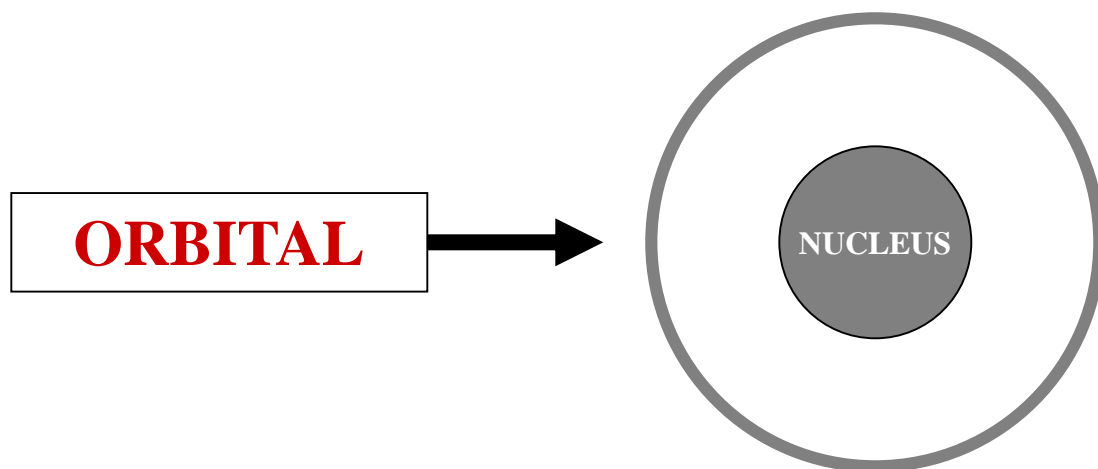
TYPICAL ATOM

E- ORBITALS & ENERGY SHELLS



TYPICAL ATOM

E- ORBITALS & ENERGY SHELLS



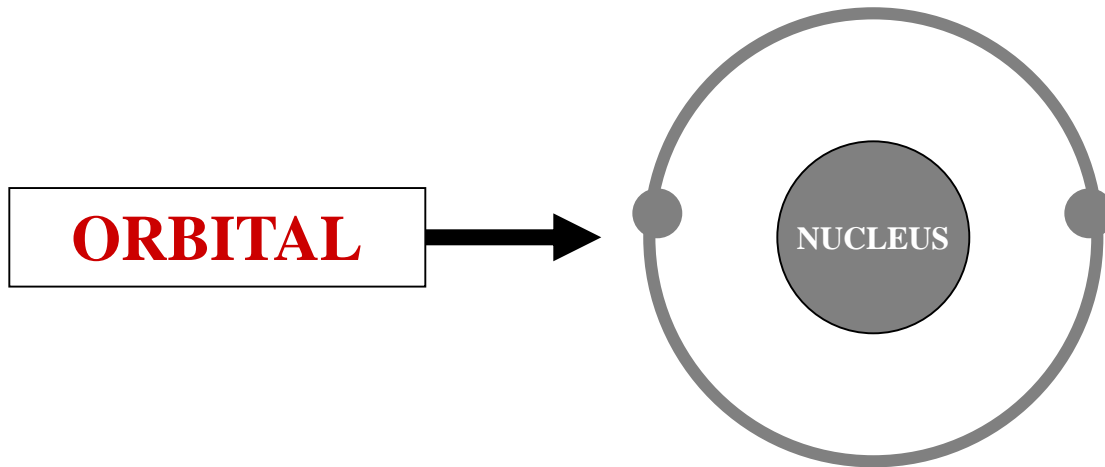
● = E-

2 E- MAX / ORBITAL

E- ORBITALS & ENERGY SHELLS

^

E



● = e-

2 e- MAX / ORBITAL

ENERGY SHELL

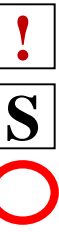


ENERGY SHELL



**POSSESSES
1 OR MORE
ORBITALS**

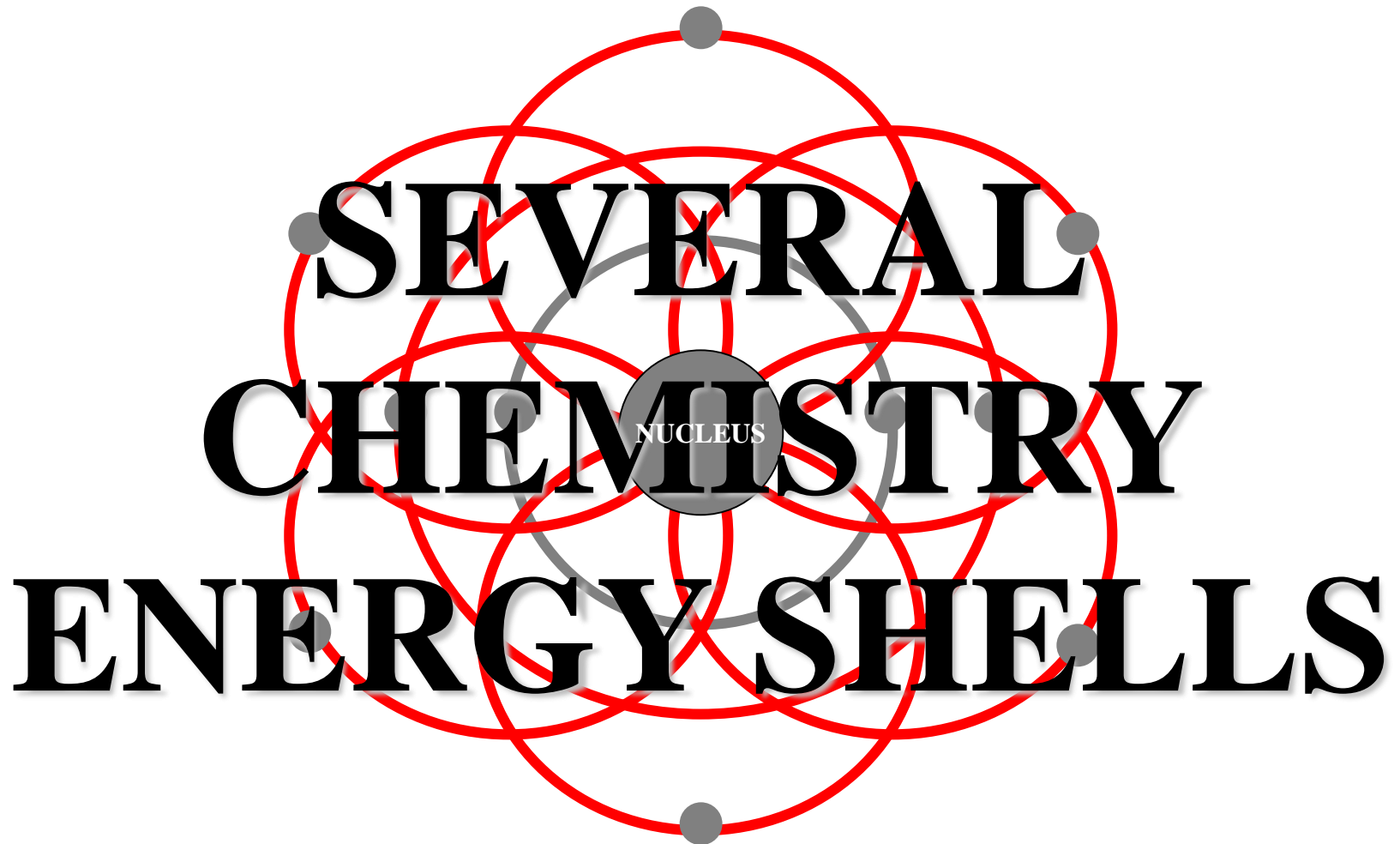
ENERGY SHELL



**ORBITAL NO.
PER
ENERGY SHELL**



CHEMISTRY ENERGY SHELLS



CHEMISTRY ENERGY SHELLS

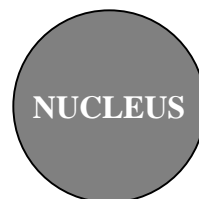
**1ST
ENERGY SHELL
ORBITAL NO.**



1ST
ENERGY SHELL
ORBITAL NO.
ONE ORBITAL

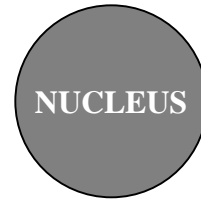
1ST ENERGY SHELL = ORBITAL NO.

1



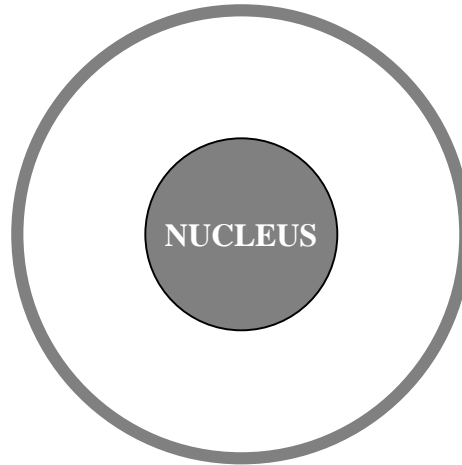
TYPICAL ATOM

1ST ENERGY SHELL = 1 ORBITAL



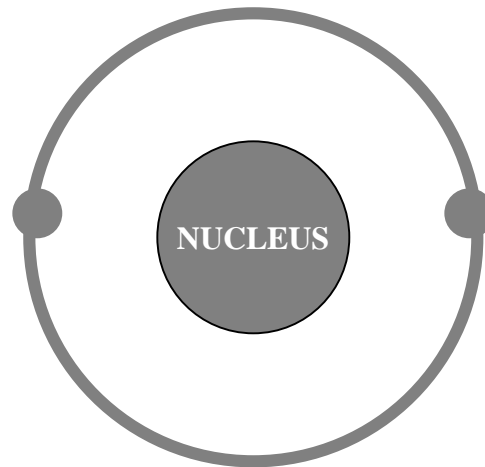
TYPICAL ATOM

1ST ENERGY SHELL = 1 ORBITAL



TYPICAL ATOM

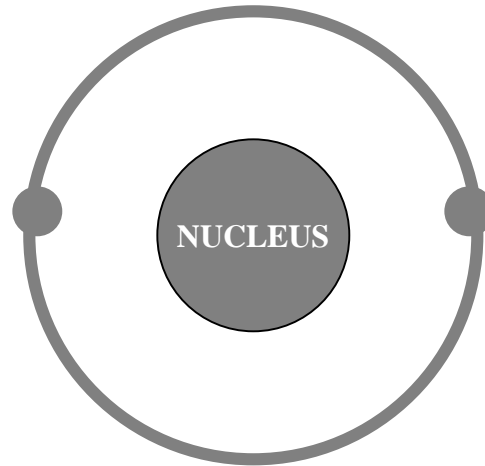
1ST ENERGY SHELL = 1 ORBITAL i 2



● = e-

2 e- MAX / ORBITAL

1ST ENERGY SHELL = 1 ORBITAL



● = e-

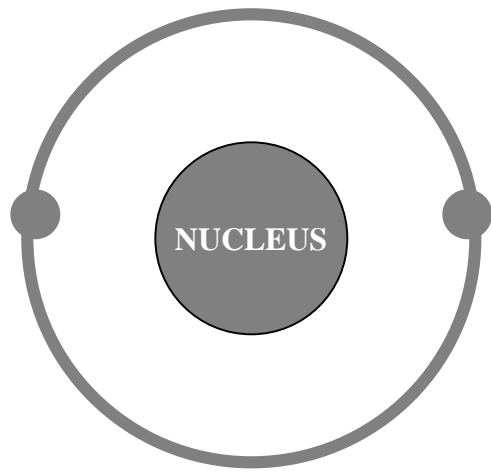
1ST E.S. = 2 e- TOTAL

**2ND
ENERGY SHELL
ORBITAL NO.**



2ND
ENERGY SHELL
ORBITAL NO.
FOUR ORBITALS

2ND ENERGY SHELL = ORBITAL NO.

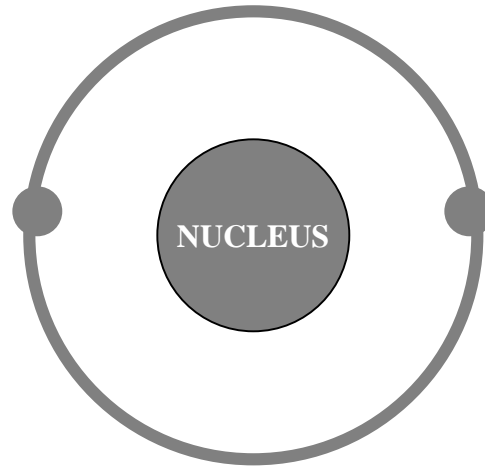


— = 1ST EGY SHELL

● = E-

TYPICAL ATOM

2ND ENERGY SHELL = 4 ORBITALS

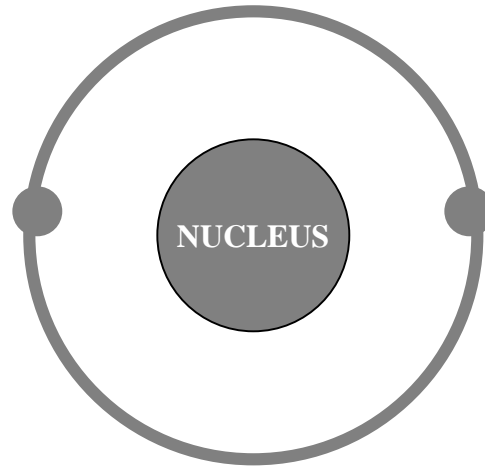


— = 1ST ENERGY SHELL

● = e-

TYPICAL ATOM

2ND ENERGY SHELL = 4 ORBITALS [©]



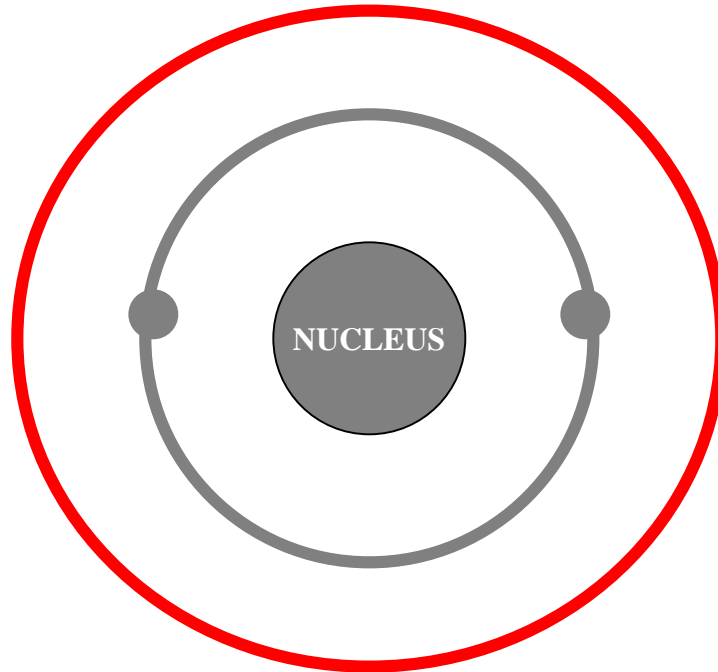
— = 1ST ENERGY SHELL

— = 2ND ENERGY SHELL

● = e-

TYPICAL ATOM

2ND ENERGY SHELL = 4 ORBITALS



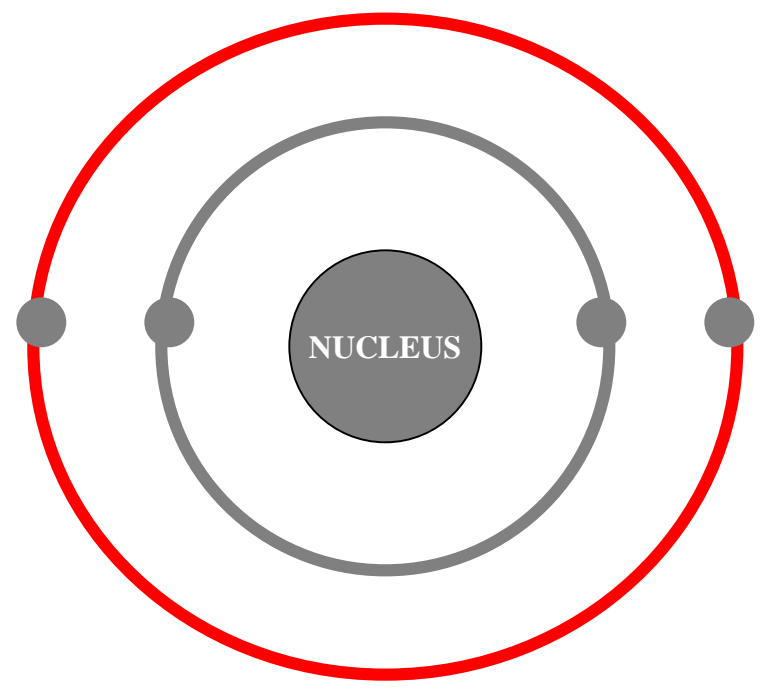
— = 1ST ENERGY SHELL

— = 2ND ENERGY SHELL

● = E-

TYPICAL ATOM

2ND ENERGY SHELL = 4 ORBITALS



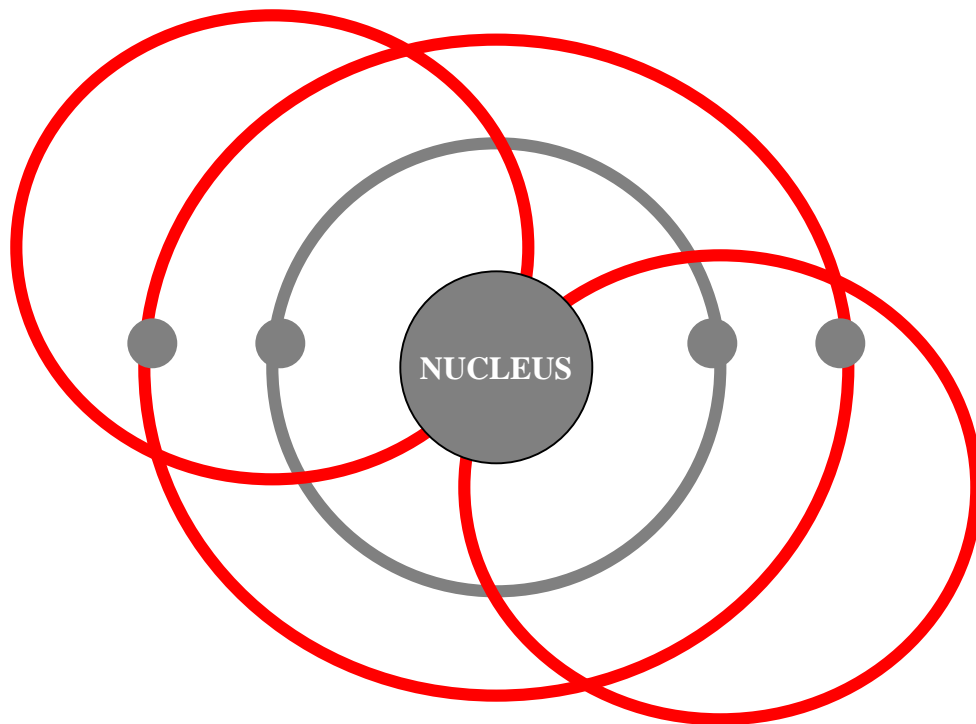
— = 1ST ENERGY SHELL

— = 2ND ENERGY SHELL

● = e-

TYPICAL ATOM

2ND ENERGY SHELL = 4 ORBITALS



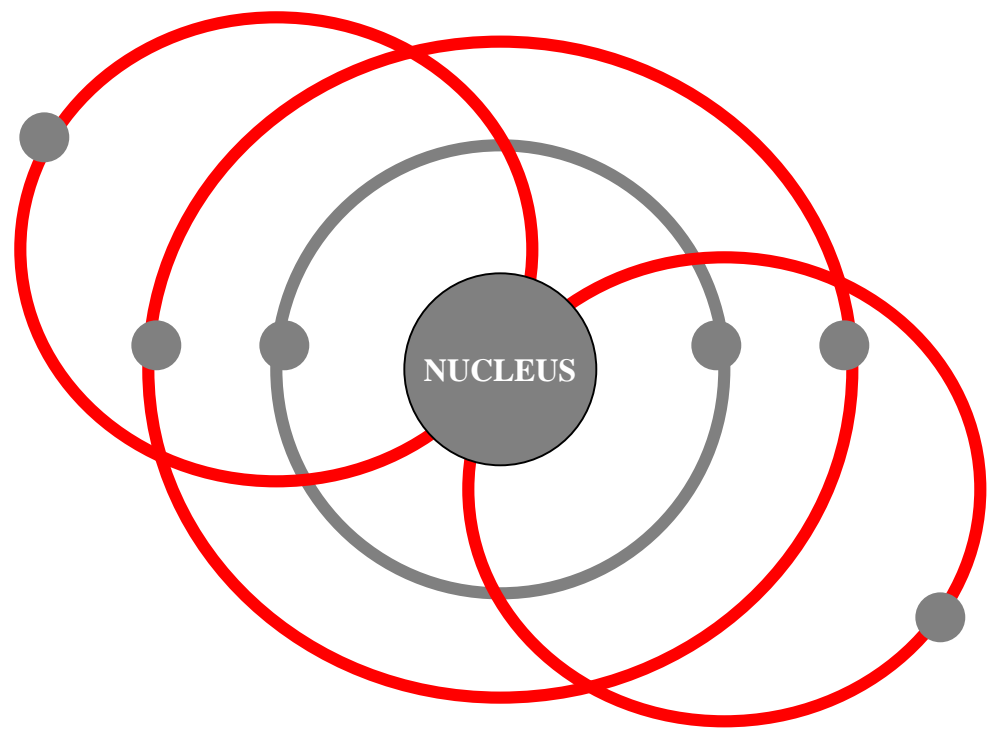
— = 1ST ENERGY SHELL

— = 2ND ENERGY SHELL

● = E-

TYPICAL ATOM

2ND ENERGY SHELL = 4 ORBITALS



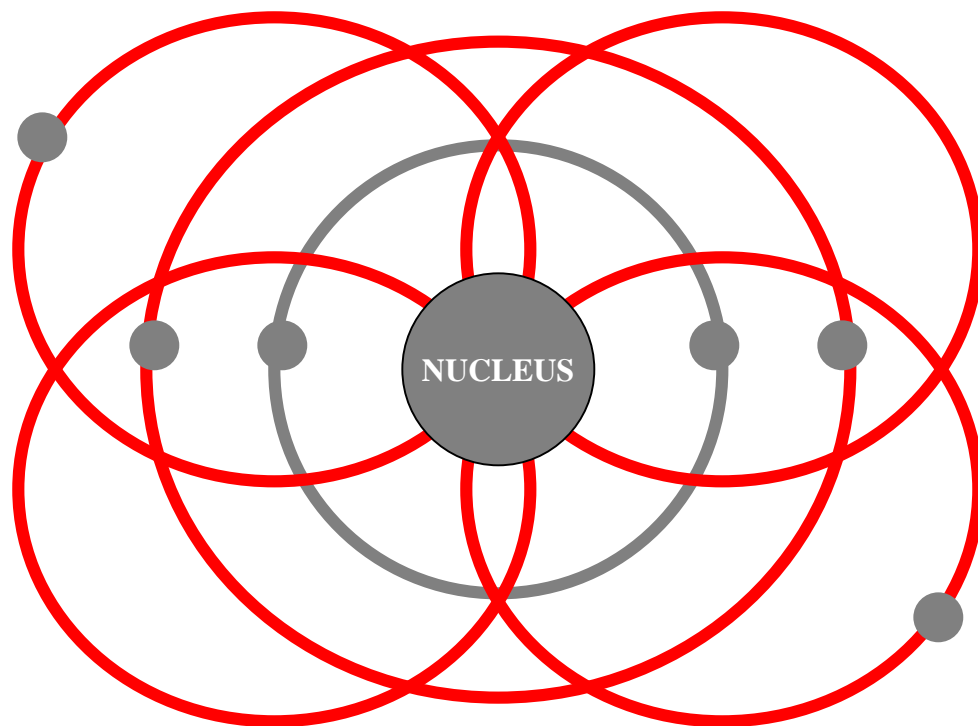
— = 1ST ENERGY SHELL

— = 2ND ENERGY SHELL

● = e-

TYPICAL ATOM

2ND ENERGY SHELL = 4 ORBITALS ^{E-}



— = 1ST ENERGY SHELL

— = 2ND ENERGY SHELL

● = E-

TYPICAL ATOM